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Rita Abdelnour

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THE USE OF ECONOMICS EXPERIMENTS
TO UNDERSTAND PATENT LICENSING, PATENT CHALLENGING AND
PATENT LITIGATION BEHAVIOR

by

Rita G. Abdelnour

A THESIS

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THE USE OF ECONOMICS EXPERIMENTS
TO UNDERSTAND PATENT LICENSING, PATENT CHALLENGING AND
PATENT LITIGATION BEHAVIOR

Rita Gaby Abdelnour, M.S.

University of Nebraska, 2009

Adviser: Amalia Yiannaka

The existing patent literature suggests that the patent breadth is an important factor in determining the innovator's patent licensing and litigation behavior and that licensing a patent to a competitor is driven by profit. The present study develops two economics experiment to investigate these assumptions.

First, a choice experiment is developed to investigate the patentee's objective when licensing her innovation, by examining whether, when the decision to license is made, the patentee maximizes profits or her strategy is to maintain a dominant market position by controlling the largest market share. The results show that the assumptions of profit maximization and licensing to weak competitors in an effort to leave strong competitors out of the market are not always true. Rather the innovator's incentives concerning patent licensing depend on the market structure and the innovator's beliefs regarding existing rivals.

A second interactive experiment is developed to investigate the effects of the breadth of patent protection and the cost structure of a potential licensee on an innovator's decision to license her patent and to litigate under infringement as well as on the likelihood of a patent challenge under six different market conditions. The likelihood

of licensing occurrence is affected by the patent breadth and the nature of the potential entrant under specific market conditions. The likelihood of an innovator making the decision to offer a license is found to be greater with broad patents regardless of the type of the potential entrant. The likelihood of patent challenge is found to be greater with a broad rather than a narrow patent and when no licensing offer is made by either the patentee or the potential entrant. Also, a weak rival is more likely to challenge a patent than a strong rival. Finally, the likelihood of an innovator invoking an infringement trial is greater when she holds a narrow patent, as suggested in the patent litigation literature, and when she faces a strong rival.

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CHAPTER I

INTRODUCTION

“Science does not know its debt to imagination”

Ralph Waldo Emerson

“Experiments are a powerful method for the discovery of where the theory works”

Francesco Guala

1.1. Statement of the problem

Technological change and global competition have made innovation activities a crucial means for the survival of companies that strive to compete in the world market and meet changing consumer preferences. Designing and developing new products and services can be very costly and companies may not undertake research and development (R&D) costs if they do not have the means to recoup their investments. Patenting is the strongest form of intellectual property protection that grants exclusivity to an innovator over his invention for a fixed period of time, enabling him to create a limited monopoly over his innovation. By granting exclusive rights as a reward for a new invention, the patent system provides the innovator with incentives for R&D and encourages in return the disclosure of information. It also encourages the production of improved and alternative products as rival companies work to develop workarounds to already existing patented inventions.

Despite the protection it grants to innovators, a patent is not always the optimal mechanism to safeguard intellectual property (Mansfield et al. 1981; Yiannaka & Fulton

2010), recoup R&D costs and maximize the innovator's rents. As Mansfield (1984) stated, in some industries 60% of patents are effectively terminated within 4 years which is less than the statutory life of 20 years from the filing date, and a large portion of the patents are duplicated within five years (Levin et al. 1987).

Often, a company's effort to safeguard its innovations just starts with the granting of the patent. Once granted, patents can be directly and indirectly challenged. Statistics show that 6% of the patents granted by the European Patent Office (EPO) are directly challenged within nine months of the patent grant (EPO 2001) and that 80% of these patents end up being amended (Cyranoski 2004). In the United States, 75% of the patents whose validity has been directly challenged end up being amended or revoked (Barton 2000). A direct validity challenge takes place in the Patent Office and/or the court while an indirect validity challenge takes place during an infringement trial. Thus, if a patent is infringed, the patentee may file a lawsuit in order to enforce the patent. In response to the claim that she has infringed the patent, the accused infringer might challenge the validity of the patent and as a result of this challenge the patent might be invalidated, revoked or amended. In fact, half of the patents whose validity has been challenged indirectly are found to be invalid (Miller and Davis 1990). However, many patents are not enforced by litigation. Instead, a patentee may find it optimal to resolve a dispute privately through licensing where the patentee allows the use of the patent in exchange of a certain royalty.

A number of studies has shown patent breadth – the technological territory claimed and protected by the patent and determined to a great extent by the innovator during the patent granting process – to be an important determinant of patent litigation

(see Yiannaka & Fulton 2006 and Yiannaka 2009 for a discussion). In general, the broader the patent breadth, the more difficult is market entry by potential competitors without infringing the patent but also the higher is the likelihood of patent challenge and invalidation (Lentz 1988, Merges and Nelson 1990). The patent breadth decision affects the innovator's ability to effectively litigate the patent and therefore affects his decision to invoke a trial under infringement as well as his decision to license the patent (Yiannaka and Fulton 2010, Fulton and Yiannaka 2009).

In fact, the decisions that characterize the innovator's patenting behavior such as patenting versus trade secrecy, determining the optimal patent breadth when patenting is chosen, licensing the innovation and finally litigating under infringement are all interlinked and crucial in determining the level of innovation rents that can be captured. It is essential for an innovator to identify the optimal strategies that will enable him to protect his invention and maximize his innovation rent.

In the economics literature, many studies empirically examined some of the above mentioned decisions (Mansfield 1986, Levin et al. 1987, Lerner 1995, Cohen et al. 2000, Hussinger 2006). The results of these studies are reported in more detail in chapter III. However, all these empirical works are based on surveys. Existing data on patent granting and patent litigation cannot be used to examine the innovator's patenting decision making process since only the final outcomes are observed (i.e., whether a patent has been licensed or whether litigation has taken place) and not the decision making process itself. This study fills this gap in the literature by using economic experiments to evaluate different aspects of the innovator's patenting behavior.

1.2. Objectives of the thesis

The objective of this study is twofold. First, the study empirically tests the assumption of profit maximization behind the licensing decision by allowing innovators to choose among profits and a dominant market share. Second, it empirically examines the licensing decision making process under different market conditions. Specifically, it examines the decision to license an innovation, the decision to challenge a patent, the litigation decision under infringement and the interdependence that exists between these decisions.

More specifically, the economic questions addressed in this study are the following:

- Examine whether innovators are more likely to maximize profits or their market share when they are making the decision to license their patents.
- Examine the effect of patent breadth and the cost structure of a potential entrant on the innovator's patent licensing and litigation behavior. Specifically we examine whether innovators are more likely to license and litigate a broad versus a narrow patent and/or license and litigate when facing a certain type of competitor (i.e., one of similar cost structure to the innovator, a low cost rival and a high cost rival).
- Examine the effect of the patent breadth on the entrant's decision to challenge the patent and test whether broad patents are more likely to be infringed than narrow ones.

- The effect of market conditions like the completeness and symmetry of information, the nature of the bargaining process (one shot versus multiple interactions) that takes place when a licensing fee is determined and the party initiating the licensing offer (innovator or entrant) on the patent licensing, patent challenging and patent litigation decisions.

Since only the ex-post decisions regarding licensing are observable rather than the decision making process itself, it is not possible to use licensing data that would serve for this study. In order to counter this obstacle, economic experiments are designed and conducted.

1.3. Methodology

Each of the above economic questions will be examined by conducting economics experiments with undergraduate students from the University of Nebraska-Lincoln as subjects. This study contains two separate economics experiments:

- In order to determine the objective of the patentee's licensing decision, an individual choice experiment is developed. The experiment contains two distinct scenarios with several rounds each. In both scenarios the subject is an innovator who has already made the decision to license. He is facing two virtual competitors (a weak competitor and a strong competitor) and is asked to make the decision as to whom to license. In the first scenario, it is assumed that the rival that was not chosen will stay out of the market, while in the second scenario the rival that did not receive a license is allowed to enter the market without a licensing contract. The experiment is set-up to examine whether, when the decision to license is

made, the patentee maximizes profits or her strategy is to maintain a dominant market position by controlling the largest market share.

- In order to examine the influence of the patent breadth, the cost structure and the market conditions on the patent licensing, patent challenging and patent litigation decisions, an interactive experiment is developed. In this experiment, subjects are paired up randomly and anonymously, with one being the innovator and the other being the potential entrant. Game trees that approximate various market conditions are developed and the subjects are asked to make decisions at each node of a given game tree that is presented to them. Each decision is associated with a given payoff. These decisions are: (1) sell or buy a license, (2) determine a licensing fee, (3) accept or reject the licensing offer, (4) in case the licensing option is not chosen or the licensing offer is rejected, the entrant has to make the decision between staying out of the market, entering the market by investing in R&D or challenging the patent via infringement, and finally (5) in case the patent is challenged, the innovator has to make the decision between invoking an infringement trial or not. Decisions 1, 2 and 3 can be made by either the innovator or the potential entrant depending on the market conditions outlined in the specific game.

The results of these experiments will help in shedding light on the determinants affecting the innovator's patent licensing and litigation behavior as well as the entrant's patent challenging behavior and in understanding the decision making process itself.

Moreover, they will allow testing empirically the predictions of the theoretical models of licensing behavior.

1.4. Organization of the thesis

The remaining chapters in this study are organized as follow: Chapter II presents a brief overview on experimental economics: its origin, growth, methodology and validity. Chapter III summarizes the existing literature on the strategic use of patent breadth and licensing as well as the litigation process. Chapter IV describes the common methodology and setting for both experiments, such as the recruitment of subjects and the preparation of the sessions. Chapter V outlines the individual experiment developed to determine the objective of the licensing decisions. Chapter VI outlines the interactive experiment developed to examine the effect of the patent breadth, cost structure of the potential entrant and market conditions on the patent licensing, patent challenging and patent litigation decisions. Finally, Chapter VII concludes the thesis.

CHAPTER II

BRIEF OVERVIEW ON EXPERIMENTAL ECONOMICS

2.1. Introduction

Economics has historically been viewed as a theoretical discipline with no room for experimental procedures. The reservation in considering economics as an experimental science dates back to the nineteenth century. English political economist John Stuart Mill (1836, p.124) raised several obstacles such as the impossibility of controlling key economic variables, and of keeping background conditions fixed so as to check the effect of manipulating each cause in isolation (Guala 2008). However, the use of experimental methods in economics has come a long way since then, especially starting the second half of the twentieth century. Guala (2008, p.1) considers that “like many other new developments in the social sciences during the second half of the twentieth century, experimental economics is largely a by-product of the combination of massive investments in science, a fertile intellectual culture and socio-political conditions in the 1940s and 50s in the United States”.

Following the steps of mathematical economics, econometrics and game theory that started as separate topics and moved gradually to become well established tools in economics, experimental economics started its transition from a topic practiced by specialists to a tool (Morgan 2003, Samuelson 2005). Nowadays, economists are more and more relying on experiments in which subjects' behavior determine how much money they earn to generate data that will help answering economic questions or testing

existing theories (Roth 1993). After all, as Friedman and Sunder (1994, p.1) mention in their book, “History suggests that a discipline becomes experimental when innovators develop techniques for conducting relevant experiments”.

2.2. General definition of experimental economics

Experimental economics can be defined as the use of experimental methods in a controlled environment. Vernon Smith (1994) identified seven reasons that explain why economists conduct experiments: (1) test a theory, or discriminate between theories, (2) explore the causes of a theory’s failure, (3) establish empirical regularities as a basis for new theory, (4) compare environments, (5) compare institutions, (6) evaluate policy proposals, and (7) the laboratory as a testing ground for institutional design. The controlled environment provides the advantage of isolating the effect of all variables other than the variable of interest, allowing answering directly a specific question using cash motivated subjects.

Many references attribute the origin of experimental economics to Edward Chamberlin who examined a market institution under controlled conditions in his classroom in 1948. However, the use of experimental methods in economics can be traced back to Thurston (1931) who worked on fitting experimentally individuals’ indifference curves, his work being later picked up by Rousseas and Hart (1951). Roth (1988) mentions that the origin of experimental economics can even be traced back to Bernouilli in 1738 who conducted informal experiments in economics.

It is a common belief that von Neumann and Morgenstern’s work, *Theory of Games and Economic Behavior* (1944) had a great influence on the emergence of

experimental economics (Roth 1993, Guala 2008). Some of the early experimental works between 1930 and 1960 involved expected utility theory (i.e., Allais 1953, Edwards 1953), effects of market institutions on the convergence toward equilibrium by redesigning Chamberlin's experiments (Smith 1962) and bargaining behavior (Siegel and Fouraker 1960). Starting the 1960s, experimental economics experienced a considerable growth and became more and more supported and funded (Hagel and Roth 1995). According to Sunder (2006, p. 22), "economics experiments can yield a great deal of data, limited only by the interest and imagination of the experimenter and the ingenuity in capturing the data without significantly distracting the subjects from their substantive task". They are applied in market, bargaining, decision making, games, auctions, as well as being used in classrooms to teach microeconomics theory.

2.2.1. Source of data

Since the birth of experimental economics, laboratory experiments have been the major source of experimental data. However, more recently, economists started gathering data through field experiments, with Peter Bohm being considered the father of field experiments (Dufwenberg and Harrison 2008).

The main differences between lab and field experiment are that field experiments take place in the natural environment of the agent being observed versus the artificial environment designed for the purpose of the experiment and that the subjects used are recruited from the market of interest (Friedman and Sunder 1994, List 2008). Harrison and List (2004) differentiated the different sources of gathered data by proposing the following classification: (1) conventional lab experiment, (2) artefactual field

experiments, (3) framed field experiment, (4) natural field experiment. Therefore, field experiments stand somewhere between laboratory experiments and naturally occurring field data (List 2008).

2.2.2. Individual versus interactive experiments

In both, lab experiments and field experiments, there are two types of experiments that can be conducted depending on the nature of the economic question addressed: individual choice experiments and interactive choice experiments. The first type does not involve any interaction between the subjects participating in the experiments and its objective is the study of individuals' choices or the decision making processes. On the other hand, interactive choice experiments allow for interactions between the subjects (Starmer 1999). Siegel and Fouraker stress the importance of anonymous interaction between subjects in their experiments to avoid the introduction of uncontrolled "social" phenomena (Roth 1993).

2.2.3. Methodological guidelines

In order to be successful, economics experiments should follow a number of basic golden rules which are listed below.

- Use of real incentives to motivate subjects: Siegel was the first experimenter to stress the importance of using real incentives to motivate subjects (Guala 2008).
- Clear instructions and demonstrations
- Avoidance of deception

- Avoidance of a bankruptcy problem that might generate risk seeking behavior in subjects since negative payments are not credible.
- Avoidance of exposing subjects to the goal of the experiment to avoid contamination of the results.

2.3. Validity and criticism

Despite their growing importance, economics experiments are often challenged and criticized for their internal and external validity (Friedman and Sunder 2004, Guala 2005b).

- Internal validity refers to the inferences made from the experiment about individual behavior. This problem can be taken care of with proper experimental design and data analysis.
- External validity refers to the generalization of the inferences to the real world and is due to the artificiality of the settings of the experiments.

In defense against these criticisms, Smith (1982) states four “percepts” that will ensure the internal validity. The percepts are nonsatiation (subjects prefer more to less), saliency (payoff linked to the actions of the subjects), dominance (payoff higher than any cost associated with participation in the experiment) and privacy (each participant knows only her own payoff). He also states a fifth percept, parallelism, that takes care of the external validity by presuming that the result can be transferred to the real world: “propositions about the behavior of individuals and the performance of institutions that have been tested in laboratory microeconomies apply also to nonlaboratory microeconomies where similar *ceteris paribus* conditions hold” (Smith 1982, p. 936).

2.4. Concluding remarks

Both, economic theory and experimental economics have limitations: Economic theory may be inaccurate, imprecise, uninformative and/or too complicated. On the other hand, experiments may be inaccurate, imprecise, uninformative and/or informative only at unreasonable cost (Samuelson 2005). In conclusion, both, economic theory and experimental economics can be combined to the benefit of each other (Samuelson 2005), and as Guala (2005, p. 194) states “experiments are a powerful method for the discovery of where the theory works”.

CHAPTER III

BRIEF OVERVIEW ON PATENT BREADTH, PATENT LICENSING AND PATENT LITIGATION

3.1. Introduction

Firms tend to protect their innovation profits with different mechanisms such as patents, secrecy, lead time advantage and the use of complementary marketing and manufacturing capabilities (Cohen et al., 2000). Often, at the firm level, firms tend to use different IP protection tools since they have more than one invention (Levin et al., 1987). Some studies showed that “firms generally do not prefer to rely on trade secrecy protection when patent protection is possible” (Mansfield 1986, p. 180) while others found that a patent is most important in protecting product innovations while secrecy is more adequate in protecting process inventions (Levin et al. 1987, Cohen et al. 2000). Hussinger (2006) analyzed the importance of patents and secrecy in protecting inventions using a sample of product innovating firms in German manufacturing in 2000 and concluded that patents are used to protect valuable inventions. The remainder of this chapter is going to focus on one form of IP protection tool, the patent, in terms of the factors that affect a patentee’s decision to license the patent and litigate it under infringement. along with all the subsequent consequences that might derive from it.

3.2. The patent: An IP protection tool

A patent is a form of IP protection tool that grants its holder exclusive rights on his innovation for a fixed period of time in return for the disclosure of information

concerning the innovation. A patent is generally characterized by its length and breadth (scope). The patent length refers to the statutory life of the patent and is predetermined by law (20 years) while the patent breadth is defined as the technological territory claimed and protected by the patent. O'Donoghue et al. (1998) introduced the notion of effective patent life which they define as the expected time until a patented product is replaced in the market and which is determined by both the patent length and the patent breadth. It is the effective patent life that determines the return from innovation to the innovator.

Patent protection is costly but necessary. It is costly because it creates market power and it is necessary because the costs of invention are very high (compared to really low when reproduced), and in the absence of protection the innovator might end up not benefiting from his innovation (Hopenhayn and Mitchell 2001). For a patent to be granted, the innovator should prove the novelty, utility and non-obviousness of the invention. However, once granted, a patent does not guarantee the patentee protection for the entire patent life. In fact, as mentioned in chapter I, the validity of a patent can be challenged directly in the Patent Office or the courts or indirectly during an infringement trial and the outcome of the challenge might result in the patent being revoked or its scope narrowed.

3.3. Strategic use of patents

Patent holders are entitled to some exclusive rights that will help them compete with their rivals. These rights are (1) the right to license or not, (2) the right to change licensing terms, (3) the right to settle patent litigation and (4) the right to offer package licenses. Patents also allow the patentee to increase the competitor's costs by using a litigation

strategy, threatening of a lawsuit to coerce the acceptance of a licensing contract or a package of licenses (Rubinfeld, 2004).

3.4. Patent breadth

The patent can be either broad or narrow. The traditional view has been that the reward to the innovator is maximized when a broad patent is claimed (Merges and Nelson 1990, Gilbert and Shapiro 1990). However, Yiannaka (2002) developed theoretical models that showed that narrow patents may be optimal and preferable to broad ones; the variables affecting the patentee's breadth decision are the potential competitors' R&D effectiveness, the legal costs incurred by the patentee and the entrant during an infringement trial and during a direct validity challenge, the degree that patent breadth affects patent validity, the level of monopoly profits realized by the patentee when entry does not occur, the level of duopoly profits realized by the patentee and the entrant when entry occurs and the discount rate.

The existing patent literature suggests that the breadth of a patent is an important factor in determining the innovator's licensing and litigation behavior. Studies have shown that broad patents can encourage technology licensing (Gambardella et al. 2007) and can reduce the incentive of the licensee to terminate the licensing contract as well as his incentive to compete aggressively with the innovator (Gallini 2002). In addition, broad patents are often associated with a higher likelihood of being challenged directly or indirectly and the outcome of these challenges is more likely to be unfavorable to the patentee, e.g. the patent can be revoked or amended (Lentz 1988, Merges and Nelson 1990, Lanjouw and Schankerman 2001). Yiannaka (2009) found that the greater the

patent breadth, the lower the entrant's incentive to develop a process that doesn't infringe the patent and the higher his incentive to infringe the patent.

3.5. Patent licensing

A license authorizes the licensee to use a patented innovation without the risk of facing an infringement trial in return for a royalty fee. Existing studies on licensing establish its important impact on the diffusion of technology, the duplication of research and product market competition (Rockett 1990, Gallini 1984). Licensing to a competitor is attributed to a profit motive or strategic incentive (Hsu and Wang 2004).

Theoretical studies on licensing suggest that licensing can be used strategically as a way of (1) letting a competitor enter the market while taking away its incentive of conducting R&D that would make him a fiercer competitor (Gallini 1984), (2) crowding the market with weak competitors to keep the strong competitor out (Rockett 1990), (3) inducing the entrant to invest in a product quality that maximizes joint profits (Fulton & Yiannaka, 2009), (4) avoiding patent litigation by settling (Meurer 1989). In addition, a patent holder is more likely to license a technology in the presence of moral hazard than under symmetric information (Schmitz 2007).

3.6. Concluding remarks

The present study extends the existing patent literature by empirically testing (1) the assumption of profit maximization when the decision to license a patent is made (2) examining the effects of patent breadth and the nature of a potential entrant on patent licensing, patent challenge and patent litigation behavior under different market

conditions using economics experiments. The economics experiments developed along with the findings are described in Chapters V and VI. These experiments should be seen as a first step towards the empirical study of the patent licensing, patent challenge and patent litigation decision making process.

CHAPTER IV

COMMON SETTINGS FOR BOTH EXPERIMENTS

This chapter discusses the procedure that is common in conducting the two experiments. It includes the choice and recruitment of the subjects, the organization of the sessions, the payment of the subjects and finally the data storage.

4.1. Pre-session

4.1.1. Choosing the subjects

The subjects used in this experiment are undergraduate students at the University of Lincoln-Nebraska pursuing different majors at the College of Agricultural Sciences and Natural Resources (CASNR), the College of Business Administration (CBA) and the College of Engineering. For the first experiment, we recruited students from CASNR and CBA only while in the second experiment we extended the recruitment to include all undergraduate students registered in the summer session at UNL.

The use of undergraduate students as subjects is common and popular in experimental economics (Chamberlin, 1948; Frykblom and Shogren, 2000; Smith, 1965). It is mainly due to the “ready access to the subject pool, convenience in recruiting on university campuses, low opportunity cost of student subjects, relatively steep learning curve and some lack of exposure to confounding external information” (Friedman and Sunder, 1994, p. 39); thus, their classification as “convenience sample”. The appropriateness of the use of such a “convenience sample” in laboratory economics experiments is an issue that has received a lot of attention in the literature. While some

studies claimed a greater homogeneity among subject samples (Calder et al. 1981) and advised caution in the use of students in experimental economics (Peterson 2001), other empirical studies found similar behavior between student and non-student subjects in contingent valuation and willingness to pay experiments (Dyer et al. 1980; Maguire et al. 2003; Smith and Mansfield 1998; and Taylor 1998).

Particularly, Dyer et al. (1980) compared the behavior of business experts and ‘naïve’ student subjects in a common value offer auction experiment and found that the winner’s curse phenomenon extended to both types of subjects: students and business executives; in other words, the experts made the same errors as the ‘naïve’ students and the results collected were similar across the subjects’ population. Moreover, in a bilateral bargaining experiment, Siegel and Harnett (1964) compared the bargaining behavior of students and experienced General Electric salesmen and found them to be similar and to conform to the theory. In addition, Harrison and Lesley (1996) replicated a survey performed by Carson et al. in 1992 to assess the damages created by the Exxon Valdez¹ oil spill using college students in South and North Carolina and found similar results by allowing for a re-weighting of the responses from the students’ population at a fraction of the costs (\$2,500 in the Harrison and Lesley’s survey compared to \$3,000,000 in the Carson et al.’s survey according to Passell (1993, p.200)). They concluded that the responses from convenience samples and from the population are similar, conditional on demographic characteristics. Other studies showed that professionals tend to ignore the instructions of the experiments and play the game the way they are used to (Anderson

¹ The Exxon Valdez spilled an estimated 10.8 million gallons of oil in Alaska in March 24, 1989 causing one of the largest ecological disasters.

and Sunder 1995). In the words of Lusk and Shogren “a theory is a generalization that should hold for everyone, *including students*” (Lusk and Shogren 2007, p.46)

It would be interesting to replicate our experiments, at a later stage, using innovators instead of undergraduate students and compare the results from the two groups.

4.1.2. Recruitment

Undergraduate students from CASNR, CBA and for the second experiment from all the colleges at UNL were recruited via an email announcement sent directly to their email accounts. The announcements which are presented in Appendices A₁ and B₁ for experiments one and two, respectively, are based on an announcement example given by Davis and Holt (1992).

4.2. Session

Upon arrival, the subjects checked in at the entrance of the lab. Each participant was then given an identification number (ID) that he/she would keep for the entire duration of the session. The passwords were created with the first two letters referring to the major to be able to study the effect of the major on the decisions made, if any. Both experiments were computerized. The subjects had online access to the computerized experiments once they logged in using their identification number. They were able to make their decision for each round with a mouse click. The subjects’ decisions made during the first experiment were kept confidential and unknown to other subjects, while the decisions made during the second experiment were known to the player they are matched up against.

Once all participants checked in, the consent form (see Appendices A₂ and B₂ for the first experiment and the second experiment, respectively) was read aloud and the participants were asked to sign it and hand it to the assistant. The participants were asked to read the instruction sheet which was also read aloud and the participants were allowed to ask for any clarification before the session started.

Both experiments included more than one scenario and a number of rounds within each scenario. In order to examine whether the results were influenced by the order in which subjects received information, the participants were divided randomly into two groups; one where the information in the different scenarios and rounds is presented in the sequence shown in Appendices A₃ and B₃ for experiments one and two, respectively, (control group) and one where both the scenarios and the rounds within a scenario are randomized.

4.3. Post-session:

4.3.1. Payment:

When a participant completed the test, he/she came to a private corner in the room where the experiment was conducted and returned the assigned password and any documents containing instructions (for the second experiment). He/she was then handed the participation fee of \$15 in cash for the first experiment, and \$10 in cash for the second experiment plus any additional earnings from playing the game. The participants in the second experiment could earn up to an additional \$20 depending on the decisions they made during the experiment. Each participant was asked to write his/her NU ID, the

amount of money he/she earned and his/her signature on the receipt forms for records and grant reimbursements.

4.3.2. Storing the data:

At the end of a session, the participants' lists, assistants' names, earnings/participation fees, and receipt forms were stored in a folder. Since the experiment was performed in several sessions, the observations were pooled. Access to the data was limited to the authors of the study.

CHAPTER V

TESTING PROFIT MAXIMIZATION AS A DRIVER BEHIND THE INNOVATOR'S PATENT LICENSING DECISION

5.1. Introduction

This first experiment attempts to shed light on the objective behind the patentee's licensing decision by examining whether, when the decision to license is made, the patentee maximizes profits or her strategy is to maintain a dominant market position by controlling the largest market share. The existing literature regarding innovation, patenting and licensing assumes a profit maximizing innovator. A few studies on patent licensing (Gallini 1984, Rockett 1990) suggest that licensing can be used as a tool to choose the competition in the market by enabling the patentee to choose the competitors that would least threaten her market position and thus, her profits. For instance, Gallini (1984) shows how licensing can reduce the incentive of a potential entrant to develop a better technology and become a fiercer competitor while Rockett (1990) shows that the patentee can crowd the market with weak competitors leaving strong competitors out.

However, other objectives might drive the innovator's licensing decisions such as sales/market share maximization. It would be interesting to examine whether, when it comes to licensing, a patentee would find it optimal to sacrifice profits to maintain her dominant market share position. To answer this question, we develop a choice experiment where we consider a market in which an incumbent innovator has already developed a new product, patented it and has decided to license it. The innovator could license its product to two types of potential competitors: a weak competitor and a strong

competitor. For simplicity, the innovator is going to face only two firms, one of each type, while the type of a competitor is defined by its cost structure. The strong competitor, firm E_s , is assumed to have lower production costs than the incumbent patentee, I , while the weak competitor, firm E_w , is assumed to have higher production costs than both the incumbent firm I and the strong potential competitor, E_s . Typically in a setting like this, if the innovator was maximizing profits, once the innovation was licensed, the innovator and the entrant would be competing in the market producing a homogenous product. If the innovator licensed the product before starting production a Cournot duopoly game could determine the market price, quantity and the market share of each firm while if the innovator licensed the product after she introduced it to the market, the market price, quantity and the market share of each firm could be determined through a Stackelberg type game.

In this experiment we assume that when the incumbent licenses to the strong competitor she captures a smaller market share than when she licenses to the weak competitor but her total profit (including the royalty payments) are greater when she licenses to the strong rather than to the weak competitor. This would be consistent with a situation where the royalty fee is the same for both potential entrants and it is output based (in a Cournot setting the low cost firm will produce a larger quantity and pay a larger royalty fee than the high cost firm) and/or when a higher royalty fee is charged to the strong competitor who has more to lose by staying out of the market and might thus be willing to pay more to enter the market. Therefore, we set up the market so that there is a tradeoff between profits and market share when licensing to the weak versus the

strong competitor that the patentee should take into account when she makes her licensing decision.

The experiment consists of two scenarios each divided into several rounds. In each scenario and round all subjects are considered as innovators and each of them faces two virtual types of potential entrants: weak and strong. The choice of virtual competitors allows us to focus on examining the behavior of the incumbent rather than both the incumbent and the entrant. In a future stage, the interaction between both parties could be examined following a different experimental design. The subjects are asked to choose between these two firms based on information given to them at the beginning of each scenario and round. All subjects in the same round are given the same information and payoff matrices. The following assumptions are held constant during the two scenarios and different rounds:

1. All subjects are assumed to have the same product.
2. The firm chosen by the subject will accept the licensing contract.

The assumption that the innovator always makes an offer that is profitable to both parties is made to keep the analysis simple and the focus on the innovator's objective function².

What varies under the two scenarios is the number of firms allowed to enter the industry; one firm only or both firms. The two scenarios are described as follows.

² If we were to allow the possibility that the proposed licensing contract were rejected, we would have several additional ramifications that would be easier to examine in future experiments in which we will allow interaction between the innovator and the entrants. Having real subjects as entrants will be then a necessary condition and both parties will make decisions subject to their respective objective function.

- Scenario 1: the subjects have to make the decision of licensing exclusively to either one of these firms knowing that the firm that does not receive a license stays out of the market (there is no infringement).
- Scenario 2: the subjects have to make the decision of licensing exclusively to either one of these firms knowing that the firm that does not receive a license might still enter the market by developing its own product.

5.2. Scenario 1

The assumptions made are the following: (1) Same product for all innovators, (2) the firm chosen by the innovator will accept the licensing contract: “take it as is” contract, (3) the licensee will enter the market crowding it so that there will be no possibility of entry by the firm that does not receive the license after the licensing contract has been signed.

The notation of the variables of interest is given below.

- Π_I^s : Innovator’s production profits when the strong competitor is in the market
- Π_I^w : Innovator’s production profits when the weak competitor is in the market
- Φ_I^s : Royalty fee paid by the strong competitor (function of the quantity produced)
- Φ_I^w : Royalty fee paid by the weak competitor (function of the quantity produced)
- S_I^s : Innovator’s market share when the strong competitor is in the market
- S_I^w : Innovator’s market share when the weak competitor is in the market

In this scenario, the subjects face the problem to whom to license given the following information regarding the payoff matrix:

- $S_I^s < S_I^w$: The innovator's market share is higher when she licenses to the weak competitor compared to when she licenses to the strong competitor due to her cost structure advantage over the weak competitor.
- $\Pi_I^s < \Pi_I^w$: When the innovator licenses to the weak competitor she produces more and therefore her production profit is higher.
- $\Phi_I^s > \Phi_I^w$: The royalty fee is assumed to be a function of the quantity produced. By producing more, the strong firm will be paying a higher royalty fee than its weak rival.

Setting up the total profits (i.e., production profits and royalty fee) for the subjects from licensing to each type of firm will allow us to capture their decision between a strong or a weak competitor, and hence to determine their objective when they make their licensing decision. The following cases will be examined.

Case I. $\Pi_I^s + \Phi_I^s = \Pi_I^w + \Phi_I^w$.

By setting the total profits from licensing to the strong and the weak competitor equal to each other we make licensing to the weak firm more appealing to the innovator since she will be getting exactly the same profit as if she had licensed to the strong firm while maintaining her dominant market share position. Setting total profits equal to each other won't allow us to capture the decision of interest but we can test whether the subjects understand the task and make the anticipated decision.

Case II. $\Pi_I^s + \Phi_I^s < \Pi_I^w + \Phi_I^w$.

Setting the total profits from licensing to the strong firm lower than the total profits from licensing to the weak firm won't allow us to capture the decision of interest since the

innovator will more likely license to the weak firm since she will be getting a higher profit in addition to maintaining her leadership position when it comes to market share. However, as under the first case, we can test whether the subjects will make the anticipated decision.

Case III. $\Pi_I^s + \Phi_I^s > \Pi_I^w + \Phi_I^w$.

Setting the total profits from licensing to the strong firm greater than those from licensing to the weak firm will allow us to capture the tradeoff between profits and market share. If the innovator picks the weak firm to be the licensee despite the fact that she will be earning lower profits than if she had licensed to the strong firm then we can infer that the innovator places greater importance into having the largest market share.

5.2.1. Design of scenario 1

The first scenario includes the three cases described above and has 18 rounds in total. The scenario 1 narrative and round information given to the subjects for this experiment is presented in Appendix A₃.

The following information should be given to the subjects in order to allow them to make the decision between strong versus weak competitor:

- Total profit from licensing to each type of potential entrant.
- Market share from licensing to each type of potential entrant.

Under cases I and II where the total profits from licensing to the weak competitor are, respectively, equal to and greater than the total profits from licensing to the strong competitor in addition to a general description of the market conditions the subjects are given numerical examples that will allow us to examine whether their decisions are

affected when actual values are attached to the variables of interest. Specifically, in the first round under both cases I and II subjects are given a general description of the market conditions while in the second round subjects are given numerical values where the innovator's market share is given as a percentage of the total market share and her total profits in millions of dollars. A third round is included under case II where the innovator's market share and total profits when she licenses to the weak competitor are given as a function of her market share and total profits when she licenses to the strong competitor to examine whether absolute market share and profit values have an effect on the decision making process.

In case III where the total profits from licensing to the strong competitor are higher than the total profits from licensing to the weak competitor we will be able to capture the tradeoff between profits and market share when the subjects make their licensing decision. Since this is the case of interest, this case has several rounds where a sensitivity analysis is also performed. Specifically, the analysis consists of first giving the subjects values for their market share and total profits from licensing to each type of firm and then performing a series of changes first in the market share and then in the total profits. Changing the values sequentially allows us to test the sensitivity of the subjects' decision to different proportions of market share and total profits. It also helps us determine what drives the change in a decision, if a change occurs.

5.3. Scenario 2

In this scenario, the innovator still provides exclusive licensing to one firm but the assumption that the firm that does not receive a license stays out of the market is relaxed.

Thus, under this scenario the competitor that does not receive the license may be able to enter the market, in which case the proportion of the innovator's market share and total profits will be affected. When making her licensing's decision, the innovator will know the likelihood of entry by the rival that does not receive a license which she should take into consideration when making her licensing decision. The weak rival is assumed to enter the market with a close substitute if he is not given the license but is nevertheless successful in generating a non-infringing product, while the strong rival is assumed to enter the market with a better product if he is not given the license but he has nevertheless succeeded in generating a non-infringing product.

Market entry by the competitor that does not receive the license might lead to different outcomes regarding market shares and total profits. However, in this scenario, we are only interested in the cases where an initial outcome presented to the subjects may be reversed with a given probability. Specifically, under this scenario, the initial outcome will always refer to a market outcome where licensing to the weak rival leads to greater market share while licensing to the strong rival leads to great profits for the innovator (as under case III in scenario 1). The subjects will need to make their decisions knowing that there is likelihood that the outcome of this decision may be reversed. For instance, when licensing to the weak competitor there will be a probability that the strong competitor will enter the market, in which case the innovator will lose her leadership position and similarly when licensing to the strong competitor there will be a probability that the weak competitor will enter the market, in which case the innovator will lose her profit

advantage. Under this scenario, we want to examine whether the likelihood of this reversal in the initial market outcome affects the innovator's licensing decision.

5.3.1. Design of scenario 2

The second scenario has 11 rounds in total and includes the two cases described above in which the subjects face a probability of having the final outcome from scenario 1 reversed: likelihood of losing the leadership in market share when licensing to the weak rival and likelihood of losing the higher profit when licensing to the strong rival. In each round, a different probability of entry of the non-licensed rival is assigned. This will allow us to test at which probability the subject is more likely to change (if a change occurs) his/her decision as to whom he/she is going to license and hence his/her objective function.

The first four rounds in the second scenario are composed of two parts each. The first part introduces the subjects to a round similar to the ones they saw in scenario 1 and requires them to make the same type of decision as in the previous scenario: licensing to the weak rival or licensing to the strong rival. Depending on the subject's choice in this part he/she will be directed automatically to the appropriate second part where the probability of entry of the second rival without a licensing contract is introduced along with the outcomes of the entry: the new market share and actual total profits. The subjects will have to decide then whether they want to keep their previous decision and still license to the chosen rival in part 1 or change it and license to the second rival. The expected total profits are not given to avoid confusion when comparing the new outcome with the ones given in the first part of the round. The first part of all four rounds is kept

the same. The only difference between these four rounds is the probability of entry introduced in the second part. The probability will increase from one round to the next by the increment of 20%, going from 20% to 80%.

The last 7 rounds in scenario 2 are also composed of two parts each. However, in these rounds, the subjects are asked to make one single decision versus the two decisions they had to make in the first four rounds of scenario 2. The first part of these rounds is the same as the first part in the previous rounds. However, now, the subjects have complete information of the situation before they make their decision. In other words, they are given the probability of entry of both rivals without a license contract along with the outcomes of the entry and then they are asked to make their decision to whom they want to license. In addition, the last three rounds assume a fixed probability of entry without a licensing contract for the weak rival (20%) while the probability of entry without a licensing contract for the strong rival is allowed to vary (40%, 60% and 80%) since the strong rival has a higher probability of entering the market without a licensing contract and without infringing the patent due to its low cost structure (higher R&D). The purpose of the last 7 rounds is to examine whether the subjects' choice is affected by the way they receive information, i.e., information is given sequentially as decisions are made (first 4 rounds) versus information is given ex ante, before decisions are made (last 7 rounds).

5.4. Results and discussion

Sixty undergraduate students participated in the choice experiment. They were recruited from the College of Agricultural Sciences and Natural Resources (CASNR) and the College of Business Administration at UNL and were paid \$15 each in cash for their

participation. They were divided into two groups, a control group and a treatment group. In the control group, 20 participants took the experiment in the order that the rounds appear in Appendix A₃; while in the treatment group, 40 participants took a randomized version of the experiment where both, the rounds within each scenario and the order of scenarios were randomized (some subjects saw the rounds of scenario 1 before the rounds of scenario 2 while others saw the inverse). The purpose of the randomization is to examine whether the results are influenced by the order in which subjects receive information. From the 40 students that took the randomized version of the experiment, 18 subjects started with scenario 1 and 22 subjects started with scenario 2. The approximate average duration of the experiment was 16 minutes for the control version and 15 minutes for the randomized version.

5.4.1. Results and discussion of scenario 1

5.4.1.1. Data and data edits

The first scenario has 18 rounds and 180 observations in total. The first 5 rounds correspond to cases I and II described previously where the optimal choice would be licensing to the weak rival. These 5 rounds won't allow us to capture the decision of interest but will allow us to test the results obtained from subjects who may make "irrational" decisions and examine whether the subjects understand the experiment and make the 'anticipated' decision, i.e., choosing more rather than less, thus, satisfying the nonsatiation percept as described by Smith (1982). In other words, these first 5 rounds enable us to monitor the subjects and are not included in the analysis. For the sake of exposition, the rounds are divided into groups as shown in Table 1 below, for a total of 7

groups. The rounds of interest corresponding to case III, rounds 6 to 18, are grouped in triplets with the exception of round 6. The reason these rounds are grouped by 3 is that the parameters (market share and total profit when licensing to the weak rival and market share and total profit when licensing to the strong rival) are kept constant within the 3 rounds in a group except for one parameter that is allowed to vary in order to examine how a decision may change when the market situation changes. Specifically:

- In rounds 7 to 9 the parameters are expressed in dollar values and the total profit when licensing to the strong rival is allowed to vary while everything else is held constant.
- In rounds 10 to 12, the parameters are expressed in dollar values and the market share when licensing to the weak rival is allowed to vary while everything else is held constant.
- In rounds 13 to 15, the parameters are expressed in nominal format and the total profit when licensing to the strong rival is allowed to vary while everything else is held constant (similar to rounds 7 to 9).
- In rounds 16 to 18, the parameters are expressed in nominal format and the market share when licensing to the weak rival is allowed to vary while everything else is held constant (similar to rounds 10 to 12).

Table 1: Division of the 18 rounds

Case I	Group A	Rounds 1 & 2
Case II	Group B	Rounds 3 to 5
Case III	Group C	Round 6
	Group D	Rounds 7 to 9
	Group E	Rounds 10 to 12
	Group F	Rounds 13 to 15
	Group G	Rounds 16 to 18

The subjects' decisions are summarized in contingency tables for the first three groups and in tables for the remaining (Tables 2 to 6 in Appendix C).

The design of the experiment had some subjects taking the questions in sequential order (i.e. questions 1 through 18 were asked in order) while other subjects were randomly given the questions. Therefore a variable named order was added to the data set where "Fixed" meant that the questions were given in a sequential order while "Random" meant the questions were given randomly.

As earlier described, the first scenario consists of a set of questions having either a nominal or numerical categorization on which the subject had to base the licensing decision. The nominal categorization is the set of questions where the decisions of licensing are based on information on market share and profit that are classified as greater than, less than or equal to without specification of exact values. The numerical categorization is the set of question where exact values for market share (in percentages) and profit (in million dollars) are provided to the subjects. Therefore, the data is split into two sections to examine the consistency of the licensing decision based on general information or exact numerical information. The nominal data was gathered from questions 1, 3, 5, 6 and 13 through 18 while the remaining questions are part of the numerical data.

Within the nominal data, four variables names Market Share Weak (MSW), Market Share Strong (MSS), Profit Weak (PW) and Profit Strong (PS) are created. Market share and profit for each type of competitor is then assigned a value of Greater (G), Less (L) or E (equal). For example, question 1 has market share from licensing to the

weak competitor greater than the one from licensing to the strong competitor with equal amounts of profits. This translates into $MSW=G$, $MSS=L$, $PW=E$ and $PL=E$. The same methodology is applied to the remaining questions of the nominal data. Because knowing the market share or profit from licensing to one of the competitors automatically gives us information about the market share or profit from licensing to the other competitor (i.e. $MSW=G$ means $MSS=L$, $PW=E$ means $PS=E$, $PW=L$ means $PS=G$ and $MSW=L$ means $MSS=G$), observations having same market share structure with difference in profits are grouped into one group while observations having same profit structure but different market shares are grouped into another group. The nominal data we are interested in analyzing are Groups F and G. For questions in Group F, the variants were in the profits from licensing to the strong competitor where the values are defined as a multiple of the same unknown value. Therefore the variable PS can have three different values each of which is greater than PW. Hence, the three different values are redefined as G1, G2 and G3 where G1 meant that PS is 1.25 times greater than PW, G2 is 1.5 times greater than PW and G3 is 2 times greater than PW. A similar approach is adopted for market share in Group G.

As for the numerical data we are interested in analyzing (Groups D and E), the same four variables described earlier ($MSWN$, $MSSN$, PWN and PSN where N stands for “numerical values”) are created and the numerical information of each is attributed according to the question asked.

5.4.1.2. Statistical analysis

For both nominal and numerical data types, the analysis was performed by group of questions. The GLIMMIX procedure in SAS 9.2 © was used to run a generalized linear mixed model with the licensing decision a binary response (0=license to the weak rival, 1=license to the strong rival). In each group, the variant variable was included as a classification variable along with the subject and the order in which the questions were presented. The variant variable and the order were considered as fixed effects and interactions between the two factors were investigated. Because the same subject answered each set of questions in each group, a correlation between the random errors was assumed and First Order Autoregressive (AR1) is considered. The logit link function was used along with the binary distribution.

$$\log \left(\frac{\pi(x)}{1-\pi(x)} \right) = \text{logit}[\pi(x)] = \alpha + \beta x \quad (1)$$

or

$$\pi(x) = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}} \quad (2)$$

Where $\pi(x)$ is the probability of observing a value of 1 at a particular value of x .

All results are reported at the 0.05 rejection level.

5.4.1.3. Results

- Groups A and B:

The data shows that in Group A, 18 subjects out of the 20 subjects in the control group made the anticipated decision of licensing to the weak rival while 2 subjects did not follow the expected behavior that assumes that individuals usually prefer more to less, in

this case, having both a dominant market share and high profits (Table 2a in Appendix C). We obtained the same results in the treatment group where 38 out of the 40 subjects chose the optimal strategy (licensing to the weak rival) while 2 subjects deviated from the expected behavior (Table 2b in Appendix C). However, in Group B, all subjects made the anticipated decision and licensed to the weak rival, maximizing both their market share and their profits (Table 3 in Appendix C).

- Group C:

The data in Group C shows that only 4 subjects in the control group and 17 subjects in the treatment group chose to maximize their market share (Table 4 in Appendix C); however, when looking at the data in Groups D to G (Table 5 in Appendix C), we notice that a larger number chose the market share as incentive for licensing, which indicates that the provided values had a significant effect on the decisions.

- Group D:

In this group, the total profit when licensing to the strong rival is allowed to vary while everything else is held constant. Therefore, only the variables “PSN”, “Order” and the interaction “PSN*Order” are used to estimate the model. The results show no significant interaction between the “Order” variable and “PSN” (p-value=0.4433). Therefore the interaction term is dropped from the model. A second model, estimated using only the two variables, shows that the order of information given to the subjects has no significant effect on the decision in question (p-value=0.1215).

The reduced model including only the variable that was found to be significant is used then to provide Least Squares Means estimates of the effects of the variables on the licensing decision (Table 7a in Appendix C). The estimated model is the following:

$$\text{logit} \left(\frac{\hat{p}(\text{license}=\text{weak})}{1-\hat{p}(\text{license}=\text{weak})} \right) = \mu + PSN_i + \text{subjects}_j + \varepsilon_{ij} \quad (3)$$

Where $i = \{592, 750, 928\}$ and $j = 1, 2, \dots, 60$

The fit of the model was deemed adequate because of the generalized chi squares over the degree of freedom of 1 which is the recommended value for the generalized linear models.

The analysis shows that as the profits from licensing to the strong rival increases, the likelihood of licensing to the strong rival decreases, which contradicts both the literature's assumptions of profit maximizing innovators and subjects preferring more to less. The estimated probabilities of licensing to the weak rival are 18.33%, 41.67% and 58.33% when the profits from licensing to the strong competitor are \$592 million, \$750 million and \$928 million respectively (Table 7 in Appendix C). The estimated odds of licensing to a weak rival are:

- 3.18 times greater when the total profit from licensing to the strong rival is \$750 million than when it is \$592 million;
- 6.25 times greater when the total profit from licensing to the strong rival is \$928 million than when it is \$592 million;
- 1.96 times greater when the total profit from licensing to the strong rival is \$928 million than when it is \$750 million.

When looking at the collected data of rounds 7 to 9 provided in Table 5 in Appendix C, we notice that a large proportion of subjects made unexpected switches in their decisions in these three rounds (9 out of 20 subjects in the control group and 16 out of 40 subjects in the treatment group). These unexpected switches can be attributed to the individuals' inability to keep track of the values we gave them, even though we would expect them to have a better ability to keep track of the values in the fixed version of the experiment. This shows that some subjects optimized their objective while others did not or were not consistent: 11 subjects in the control group and 24 subjects in the treatment group stuck with their choices regardless of the changes in the market share and total profits.

- Group E:

In this group, the market share when licensing to the weak rival is allowed to vary while everything else is held constant. Therefore, only the variables “MSWN”, “Order” and the interaction “MSWN*Order” are used to estimate a model. The results show no significant interaction between the “Order” variable and “MSWN” (p-value=0.0884) and no significant effect of the order of information given (p-value=0.4418).

The reduced model including only the variable that was found to be significant is used then to provide Least Squares Means estimates of the effects of the variables on the licensing decision (Table 7 in Appendix C). The estimated model is the following:

$$\text{logit} \left(\frac{\hat{p}(\text{license}=\text{weak})}{1-\hat{p}(\text{license}=\text{weak})} \right) = \mu + MSWN_i + subjects_j + \varepsilon_{ij} \quad (4)$$

Where $i = \{60\%, 70\%, 90\%\}$ and $j = 1, 2, \dots, 60$

The fit of the model was deemed adequate because of the generalized chi squares over the degree of freedom of 1.02 which is close to the recommended value of 1 for the generalized linear models.

The results show a positive relationship between market share and licensing to the weak rival. In other words, as the market share from licensing to the weak rival increases, the likelihood of licensing to the weak rival increases. The estimated probabilities of licensing to the weak rival are 28.33%, 40% and 53.33% when the market share from licensing to the weak rival are 60%, 75% and 90% respectively (the estimates corresponding to a market share of 75% and 90% were not statistically significant). The estimated odds of licensing to a weak rival are:

- 1.69 times greater when the market share from licensing to the weak rival is 75% than when it is 60%;
- 2.89 times greater when the market share from licensing to the weak rival is 90% than when it is 60%;
- 1.72 times greater when the market share from licensing to the weak rival is 90% than when it is 75%.

The collected data for this group shows that the subjects were more consistent in their choices and few unexpected switches were made (3 in total out of the 60 subjects).

- Group F:

In this group, the parameters are expressed in nominal format and the total profit when licensing to the strong rival is allowed to vary while everything else is held constant. Therefore, only the variables “PS”, “Order” and the interaction “PS*Order” are used to

estimate a model. The results show no significant interaction between the “Order” variable and “PS” (p-value=0.7547) and no significant effect of the order of information given (p-value=0.9511).

The reduced model including only the variable that was found to be significant is used then to provide Least Squares Means estimates of the effects of the variables on the licensing decision (Table 7c in Appendix C). The estimated model is the following:

$$\text{logit} \left(\frac{\hat{p}(\text{license}=\text{strong})}{1-\hat{p}(\text{license}=\text{strong})} \right) = \mu + PS_i + subjects_j + \varepsilon_{ij} \quad (5)$$

Where $i = \{1.25D, 1.5D, 2D\}$ and $j = 1, 2, \dots, 60$

The fit of the model was deemed adequate because of the generalized chi squares over the degree of freedom of 1 which is the recommended value for the generalized linear models.

Despite the fact that this group is similar to Group D, the only difference being the values are given in a nominal format, the obtained results are completely the opposite. In this group, a positive relationship between the total profits and the decision of licensing to the strong rival is estimated: as the total profits from licensing to the strong rival increases, the likelihood of licensing to the strong rival increases. The estimated probabilities of licensing to the strong rival are 56.67%, 66.67% and 91.67% when the total profits from licensing to the strong rival are 1.25, 1.5 and 2 times greater than the total profits from licensing to the weak rival, respectively. There is no significant difference between the first two levels of profits increase (1.25 and 1.5) on the licensing decision while significant differences between the first and third levels (1.25 and 2) and

the second and third levels (1.5 and 2) are found. The estimated odds of licensing to a strong rival are:

- 8.4 times greater when the total profits from licensing to the strong rival are twice the total profits from licensing to the weak rival than when the total profits from licensing to the strong rival are 1.25 times greater than the total profits from licensing to the weak rival;
- 5.49 times greater when the total profits from licensing to the strong rival are twice the total profits from licensing to the weak rival than when the total profits from licensing to the strong rival are 1.5 times greater than the total profits from licensing to the weak rival.
- Group G:

In this group, the parameters are expressed in nominal format and the market share when licensing to the weak rival is allowed to vary while everything else is held constant.

Therefore, only the variables “MSW”, “Order” and the interaction “MSW*Order” are used to estimate a model. Even though the results show a significant interaction between the “Order” variable and “MSW” (p-value-0.0447) the interaction term is dropped because when we look at the simple effect, we find that there is no significant difference on the licensing decision between the control group and the treatment group, controlling for the market share from licensing to the weak rival. Similarly, no significant difference on the licensing decision between the three levels of market share is detected, except between G2 and G3 (1.75 and 2). When the interaction term is dropped from the model,

both variables (MSW and Order) turn out to have a non-significant effect on the licensing decision.

Therefore, despite the fact that this group is similar to Group E, the only difference being the values are given in a nominal format, the obtained results are different. While in Group E the market share played an important role in the decision of licensing, it turn out that it doesn't have any effect on the decision in question in this group, ascertaining the conclusion that there is a difference between the nominal and numerical values.

5.4.2. Results and discussion of scenario 2

5.4.2.1. Data and data edits

The second scenario has 11 rounds and 660 observations in total. As earlier described, this scenario is designed in order to examine whether the likelihood of a reversal in the initial market outcome generated from the uncertainty about the action of the non-licensed rival affects the innovator's licensing decision. It also investigates whether the subjects' choice is affected by the way they receive information, i.e., information is given sequentially as decisions are made (first 4 rounds) versus information is given ex ante, before decisions are made (last 7 rounds).

In order to perform both analyses (likelihood of switching a decision under uncertainty and the effect of the way the information is given), a variable called Info is added to the data set where Info can take on two different values: "G" for questions where the information is provided gradually in two steps to the subject and "O" for questions where the information is presented all at once. Similar to scenario 1, a variable

called Order is also added to the data set where Order="Fixed" meant that the questions are presented to the subject in sequential fixed order (i.e. 1 through 11) while Order="Random" meant that the questions are randomly provided.

The data in which the information is provided in two steps (rounds 1 to 4) is extracted from the original data and is used to investigate the effects of additional information and to primarily examine (the answer is given in the first step) a switch in the licensing decision. Therefore, a variable named Switch is added to the data where Switch=0 means that the subject did not change his/her licensing decision after the second piece of information is presented while a value of 1 means that the subject decided to change their decision. A variable called P describing the probability with which the non-licensed competitor enters the market is also added to the data, where P can take on four different values (20%, 40%, 60% and 80%).

For the analysis of the effects of the way the information is provided along with the non-licensed competitor's probability of entering the market on the licensing decision, all answers from rounds 5 to 11 are used as well as answers from the second part of rounds 1 to 4. The experiment is designed in such a way that, when the information is provided all at once, the only variants between one question and the other are the probabilities of a market entry by either type of competitors. The same applies to the second part of rounds 1 to 4 when the information is provided gradually. Therefore a classification variable describing the probability of entry by the weak competitor versus the strong competitor (PENTWS) is added to the data set and consists of two numbers separated by a comma. The first number of PENTWS is for the probability of the weak

competitor entering the market if the innovator were to license to the strong rival while the second number is for the probability of the strong competitor entering the market if the innovator were to license to the weak rival. Therefore values of PENTWS of '20,20', '40,40', '60,60' and '80,80' mean that the probability of entering the market is the same for both type of competitors while values of PENTWS of '20,40', '20,60' and '20,80' depict the case where the probability of market entry is greater for the strong competitor than for the weak.

The licensing decision is then transformed into a binary response where 0 means that the subject decided to license to the weak competitor while a 1 means that the subject decided to license to the strong competitor.

The collected data from the 60 subjects are summarized in frequency tables provided in Appendix C (Tables 8 and 9). Table 8 shows that the number of subjects that switched their decision is close to or slightly greater when the information is given all at once than when it is given gradually except when the probabilities are 80%-80%, where the difference is larger. On the other hand, Table 9 shows that for rounds 1 to 4, 39 subjects out of 60 did not switch their decisions when the probability of entry of the second rival was 20% compared to 36 subjects when the probability of entry of the second rival was 40%, 30 subjects when the probability of entry of the second rival was 60% and finally 29 subjects when the probability of entry of the second rival was 80%. In addition, the data shows that, even though the first part of the first four rounds is exactly the same among the rounds, there are cases where a subject answered differently. It is frequently observed that when a subject decided to switch his/her decision in the second

part of a round, he/she repeated the last decision made in the first part of the next round. This unexpected behavior can be attributed to the subject's being confused by the way the information is provided to them (having the same question repeated at the beginning of each of these four rounds rather than giving it once and then address sequentially all second parts) or the fact that they did not pay attention to the numbers provided which questions the ability of individuals to process information and analyze the expected probabilities.

5.4.2.2. Statistical analysis

For the analysis of the effects of additional information on a switch in the licensing decision, a generalized linear mixed model is fit using the GLIMMIX procedure in SAS 9.2 ©. Order, probability of entry by the unlicensed competitor and the primary answer variable "v" are included as fixed factors in the model. All two way and three way interactions between the fixed factors are tested for significance. The logit link function is used with the distribution considered as binary (see equations 1 and 2 above). Because all questions are asked to all subjects, residual errors are assumed to be correlated.

A generalized linear mixed model, again using the GLIMMIX procedure in SAS 9.2 © with a logit link function and a binary distribution, is also used to examine the effects of the way the information is provided and the non-licensed competitor's probability of entering the market on the licensing decision. The fixed factors included in the model are Order, Info and PENTWS. All two and three way interactions between the fixed factors are considered. A correlated residual error structure is also assumed and investigated in this analysis.

All results are reported at 0.05 rejection level.

5.4.2.3. Results

i. The decision of switching a licensing decision:

The fitted model with all possible interactions shows that there is no significant three-way interaction effect ($p\text{-value}=0.6875$) or two-way interactions. The model is refitted without any interaction terms and the variables Order and P are found to have no significant effect at all on the decision to switch ($p\text{-values}=0.8786$ and 0.1573 respectively) while the answers individuals gave in the first part of the question is found to have a significant effect ($p\text{-value}<0.0001$). The likelihood of the innovator switching his/her decision after all information is given in the second step is higher when the initial decision involved licensing to a weak rival than when it involved licensing to the strong rival regardless of the increase in the probabilities of entry by the second firm and the order of information given. Table 10 in Appendix C provides the Least Squares Means Estimates.

The fit of the model is deemed adequate because of the generalized chi squares over the degree of freedom of 1.02 which is close to the recommended value of 1 for the generalized linear models.

The estimated probability of switching a decision after the information is completed gradually is 61.60% if the innovator decided to license previously to a weak rival versus 24.82% if he/she decided to license previously to a strong rival.

The estimated odds of switching a licensing decision are 4.86 times greater when the weak rival is licensed previously than when the strong rival is.

The analysis is replicated for each different value of probability separately, and the results confirm unanimously the previous conclusion that the order of information given doesn't have any effect on the licensing decision and that the innovator is more likely to switch his/her licensing choice after receiving the complete information if he/she decided previously to license to a weak rival (Table 11 in Appendix C). The answer to the initial questions is found to have a significant effect for all probabilities except when $P=20\%$, for which there is no strong evidence of significance ($p\text{-value}=0.0517$).

- ii. The effect of the way the information is given along with the probabilities of entry by the second rival:

The fitted model with all possible interactions shows that there is no significant three-way interaction effect ($p\text{-value}=0.9509$) and two-way interactions. The model is refitted without any interaction terms and the variables Order is found to have no significant effect at all on the decision of licensing ($p\text{-value}=1078$). Because of the absence of an interaction term among the significant variables, we look at the main effects of the way the information is given and the combinations of the probabilities of entry by either rival when he/she is not the licensee.

The factor that drives the licensing decision depends on the way the information is given to the innovator. It turns out that the likelihood of choosing profits over market share is higher when the information is given all at once versus gradually (Table 12 in Appendix C):

- The estimated probability of licensing to the strong competitor is 73.90% when the information is given gradually versus 82.68% when the information is given all at once.
- The estimated odds of licensing to the strong competitor are 1.69 times greater when the information is given all at once than when it is given gradually.

The factor that drives the licensing decision depends also on the probability of market entry by the rival that does not receive a licensing contract. As the probability of entry by the second rival increases, the innovator is more likely to license to the strong rival to capture larger returns from the innovation and hence larger profits. We observe this behavior when the innovator's personal belief about the probabilities of entry by either rival are the same (20%,20%; 40%,40%, 60%,60% and 80%,80%), even though the likelihood of licensing to the strong rival decreases slightly when the probabilities are 60%,60%. The same trend is observed when the probability of entry by the weak rival is believed to be low and fixed while the probability of entry by the strong rival is believed to be higher (20%,20%; 20%,40%; 20%,60% and 20%,80% (the likelihood decreases slightly for the latter). The estimated probabilities and odds are reported in Table 12 in Appendix C.

- The estimated probabilities of licensing to the strong rival are 62.60% when the beliefs about the probabilities of entry are 20%,20% compared to 77.11% for 40%,40%, 72.94% for 60%,60%, 80.04% for 80%,80%, 75.73% for 20%,40%, 89.16% for 20%,60% and finally 85.29% for 20%,80%.

- Not all pairwise differences in probabilities of entry were significant. Significant differences are detected only between low probabilities of entry by either rivals (20%,20%) and low probability of entry by the weak rival but higher probability of entry by the strong rival (20%,60% and 20%,80%) as well as between 20%,20% and 40%,40% and 80%,80%. The likelihood of licensing to the strong rival is higher when the expected probabilities of entry by the strong rival are high.

5.5. Concluding remarks

This chapter outlined an individual experiment that was developed to investigate whether profit maximization is the motive behind the patentee's licensing decision. The experiment was run with 60 undergraduate students attending UNL.

The results show that the profit maximization assumption does not always hold. In fact, we found that the patentee's objective function from licensing depends on the market structure and on the innovator's beliefs regarding rivals. We also found that the strategy of crowding the market with weak competitors to leave strong competitors out (Rockett 1990) does not always hold true. In fact, as the probability of entry by the second rival increases, the innovator is more likely to license to the strong rival to either capture larger returns from the innovation or to reduce the incentive of the strong rival to develop a better technology and become a fiercer competitor, as Gallini (1984) suggested.

In addition, the assumption that agents prefer more to less does not hold true in all cases. The results show that agents tend often to deviate from the expected behavior. This

deviation can be explained by the fact that economic agents find it difficult to analyze complex information and calculate expected probabilities.

We also found that the order of information given to the subjects doesn't have any significant effect on the licensing decision. However, the motives behind the patent licensing decision depend on the way the information is given to the innovator. It turns out that the likelihood of choosing profits over market share is higher when the information is given ex ante versus gradually as decisions are made.

Finally, we found that the type of information (nominal values, numerical values and general description) did have an effect on the patent licensing decision.

CHAPTER VI

THE EFFECT OF PATENT BREADTH AND THE TYPE OF POTENTIAL ENTRANT ON PATENT LICENSING AND PATENT LITIGATION

6.1. Introduction

This second experiment attempts to shed light on the effect of the breadth of patent protection and the cost structure of a potential licensee on an innovator's decision to license her patent and to litigate under infringement. Specifically, the experiment tries to answer the following questions.

- Whether innovators are more likely to license a certain type of patent (broad rather than narrow patents) and/or to a certain type of entrant (low versus high cost entrant).
- Whether and how the breadth of the patent affects the probability that the patent will be legally challenged (i.e., infringed) by a potential entrant.
- Whether and how patent breadth affects the innovator's decision to invoke a trial under infringement.
- Whether the likelihood that licensing will take place is affected by: (i) whether the patentee or the potential entrant initiate the licensing process, (ii) the nature of interaction between the patentee and the entrant during the bargaining process (one shot versus repeated interaction), and (iii) the nature of information available to the patentee and the entrant when they make their respective decisions (complete versus incomplete information).

As discussed in Chapter III, the patent literature suggests that patent breadth plays a crucial role in determining the innovator's licensing and litigation behavior.

Specifically, existing studies show that broad patents can encourage technology licensing (Gambardella et al. 2007) and also encourage the licensee not to terminate the licensing contract and reduce his incentive to compete aggressively with the innovator (Gallini 2002). The literature also suggests that the validity of broad patents is more likely to be challenged directly or indirectly and that the outcome of a litigation trial will more likely not favor the patentee, e.g. the patent can be found to be invalid or its scope narrowed (Lentz 1988, Merges and Nelson 1990, Lanjouw and Schankerman 2001). It would be interesting to examine the licensing behavior of a patentee holding a broad patent versus a narrow patent and facing different types of rivals.

To test the predictions of the theoretical studies outlined above and answer the questions of interest, we develop an experiment that considers a market where an incumbent innovator has already developed a new product, patented it and has to make the decision whether to license it taking into consideration the breadth of her patent and the type of rival that she faces. The patent's breadth can be either broad or narrow while the potential entrant can be one of the following three types: a competitor of similar cost structure to the patentee, a weak competitor or a strong competitor. Similar to the first experiment, the type of the competitor is defined by his cost structure where the weak competitor is assumed to have higher production costs, while the strong competitor is assumed to have lower production costs. However, unlike the first experiment, the game is set up in a way that allows interaction between the innovator and the potential entrant.

In this case, the innovator faces a real subject as the potential entrant, who also has to make some decisions, e.g., whether to accept or reject the licensing offer, when an offer is made, whether to infringe the patent or enter with a non infringing product.

In order to keep the information provided to the subjects minimal and the game simple, the participants will not be told whether they have a narrow or a broad patent and whether they face an entrant of a certain type. Instead, they see different payoffs and different probabilities depending on the type of patent and entrant that is assigned to them under each game. Each game is referred to as a round. Every six rounds fall under a scenario and each scenario assumes different market conditions as described in detail in the following section.

6.2. Market conditions and assumptions

In this experiment, we assume a profit maximizing firm and that the innovator has to make the decision of licensing or not before starting production. In a setting like this, a Cournot duopoly game determines the profits for the innovator and the entrant.

A game tree highlighting the possible decisions for the innovator and the entrant and the probabilities and payoffs associated with each decision is provided under each round. This tree is available to both, the innovator and the potential entrant. What differ from round to round under each scenario are the payoffs and the probabilities associated with the different outcomes.

The main decisions and outcomes at each node are the following:

1. The innovator has invented a new product and has protected it with a patent. She has to decide whether to license it to a potential entrant. If she decides to license, she then has to determine the licensing fee.
2. The potential entrant has to decide whether to accept or reject the licensing offer, if an offer is made. If he accepts the offer, he pays the licensing fee, the current game ends and another game starts. The payoffs earned in this case depend on the agreed upon licensing fee. If he rejects the offer, or if the innovator decides not to license, he has to decide whether to stay out of the market, enter without infringement or enter with infringement. If he stays out of the market, he earns \$0 profit and the innovator maintains his monopoly position. If he decides to enter without infringing the patent by investing in R&D and producing a differentiated product, he faces a probability α of being successful in developing a non infringing product and a probability $(1 - \alpha)$ of failing to develop an alternative product in which case he will be staying out of the market. The R&D investment is treated as a sunk cost. Finally, if he decides to enter by infringing the patent, he faces the risk that the innovator will decide to invoke an infringement trial.
3. In the case that the entrant infringes the patent, the innovator has to decide whether to invoke an infringement trial or not.
 - a. If she decides not to go to trial, the current game ends and another game start. The payoffs earned in this case are the result of a Cournot duopoly.
 - b. If she decides to invoke an infringement trial, she will be facing a probability $(1 - \theta)$ that the patent will be found valid, hence the entrant has to stop his activity

in the market and will be out his trial costs. In case the patent is found invalid or its scope has been narrowed, the entrant carries on his activity in the market. Whether patent revocation occurs or not, fixed trial costs are incurred by both parties.

The experiment consists of six different scenarios. What varies between the six scenarios is who initiates the licensing process (the innovator or the entrant), the number of interactions among the two players (one interaction – take it or leave it offer – or multiple interactions) and the completeness and symmetry of the information available to the players.

The six scenarios are described as follows. Scenarios A to D describe the market conditions under complete and symmetric information while scenarios E and F describe the market conditions under incomplete and asymmetric information. An example of the game tree relevant to each scenario can be seen in Appendix B₃.

1. Scenario A: The innovator initiates the licensing process and determines a licensing fee. Under this scenario, only one interaction is allowed between the players and both players have access to the same game tree, probabilities and payoff information.
2. Scenario B: The entrant decides whether to seek a patent license or not from the innovator. Under this scenario, only one interaction is allowed between the players, and both players have access to the same game tree, probabilities and payoff information.
3. Scenario C: The innovator decides whether to license or not to the potential entrant. However, under this scenario, there may be multiple interactions between

the innovator and the entrant when determining the licensing fee. The number of interactions is endogenous to the players. Both players have access to the same game tree, probabilities and payoff information.

4. Scenario D: The entrant decides whether to seek a patent license or not from the innovator. However, under this scenario, there may be multiple interactions between the innovator and the entrant when determining the licensing fee. The number of interactions is endogenous to the players. Both players have access to the same game tree, probabilities and payoff information.
5. Scenario E: The innovator decides whether to license or not to the potential entrant. Under this scenario, there may be multiple interactions between the innovator and the entrant when determining the licensing fee and each player can view only their own payoffs. The number of interactions is endogenous to the players.
6. Scenario F: The entrant decides whether to seek a patent license or not from the innovator. Under this scenario, there may be multiple interactions between the innovator and the entrant when determining the licensing fee and each player can view only their own payoffs. The number of interactions is endogenous to the players.

Each scenario is divided into several rounds. What varies between these rounds are the type of patent breadth and the type of the potential entrant. Since the patent breadth can be either broad or narrow and the potential entrant's cost structure can be

similar to, higher or lower than the innovator's, each scenario contains six rounds, equal to the number of all possible combinations between the two factors.

In the various rounds patent breadth is captured by the probability assigned to the success of the entrant's R&D investment when he decides not to infringe the patent, the invalidation of the patent when the potential entrant infringes the patent and both parties end up in court and finally by the level of profits associated with each outcome.

Following the findings of empirical studies, the probabilities under each case are set as follows:

- a. Probability of success when investing in R&D
 - i. Broad patent: probability of success: 10 – 30%
 - ii. Narrow patent: probability of success: 70 – 90%
- b. Probability of patent invalidation during an infringement trial
 - i. Broad patent: probability of patent found invalid: 60 – 90%
 - ii. Narrow patent: probability of patent found invalid: 10 – 40%

The type of the potential entrant which is defined by his cost structure is captured by the probability of success and failure when investing in R&D and by the level of profits associated with each outcome. The literature does not suggest a specific range for the probability of success and failure when investing in R&D for each type of rival. However, it is assumed that a weak rival has higher production and R&D costs than both then innovator and the strong rival, while the strong rival is assumed to have lower production and R&D costs than the innovator; the weak rival earns less profit than the

strong rival when facing the same patent under the same market conditions. In addition, the weak rival has a higher probability of failure when investing in R&D.

6.3. Design of the experiment

Each scenario contains six rounds: three rounds correspond to a broad patent with a potential entrant having a similar cost structure (case 1), a higher cost structure (case 2) and a lower cost structure (case 3) and three rounds correspond to a narrow patent combined with the three cases described above, for a total of 36 rounds. Another set of 36 rounds containing all previously mentioned combinations is developed where the patent breadth is reduced and the players switch roles (i.e., the innovator becomes the entrant and the entrant becomes the innovator), for a total of 72 rounds in the second experiment.

The subjects are paid \$10 in cash for their participation in the experiment and are given the opportunity to earn up to an additional \$20 in cash depending on the decisions they make, for a potential total earning of \$30. At the beginning of the session, the subjects are paired up electronically and randomly through their assigned identification numbers with a person that is anonymous to them as they are to that person. One person is an innovator who has invented a new product and protected it with a patent and the other is a potential entrant who is considering producing and selling that product. Each pair of participants is involved in a series of small games (72 rounds). They are not informed about the number of games they will be playing to avoid giving them the incentive to make risky decisions at the beginning knowing that they have X games left to offset any losses. Halfway through the experiment, at round 37, the pair of subjects switches roles until the end of the session (the innovator in the first 36 rounds becomes

the potential entrant in the last 36 rounds). Switching the roles has been decided for the following two reasons: to avoid the bankruptcy problem and to increase the number of observations. Under each round, the potential entrant faces a probability of earning negative profits depending on his decisions (e.g., R&D costs when the entrant fails to generate a non infringing product and trial cost when the patent is found valid and the entrant is not allowed in the market) while the innovator is always guaranteed a positive payoff. Switching the roles gives both players the opportunity to make positive profits and offset any negative balance. Also, by running an additional 36 rounds with different patent breadth values we get 72 rather than 36 observations.

The subjects are divided into two groups, a control group in which the participants see the rounds in the order shown in appendix B₃ and a treatment group in which the rounds are randomized. The randomization occurs separately within the first 36 rounds and then within the last 36 rounds after the role switch has taken place to allow the subjects to be both the innovator and the entrant under all the cases and all the scenarios.

Before the subjects log in to start the computerized experiment, a brief demonstration is presented to the participants to introduce them to the 6 different scenarios and show them how to play the games. The demo presented and provided to them as a document is included in Appendix B₃ along with a game tree representing each scenario.

In order to be able to compare the effect of the market conditions on the decisions of interest (licensing, challenging and litigation), the levels of profits associated with each outcome are rescaled and the probabilities are kept the same. The first 36 rounds

represent extreme cases of patent breadth (very broad and very narrow patents) while in the last 36 rounds, the degree of breadth is reduced (the patent is less narrow or less broad), keeping the same levels of profits associated with each outcome as in the first 36 rounds to allow for comparison.

6.4. Data and statistical analysis

6.4.1. Data description

The experiment was performed over 9 sessions. A total of 96 undergraduate students participated in the experiment, 28 of which were randomly assigned to the control group and 68 to the treatment group for a total of 48 teams and 3456 observations. The average time of the experiment was 1 hour for the control group versus 1 hour and 8 minutes approximately for the treatment group. The average additional payment was \$15.31 in the control group and \$15.37 in the treatment group.

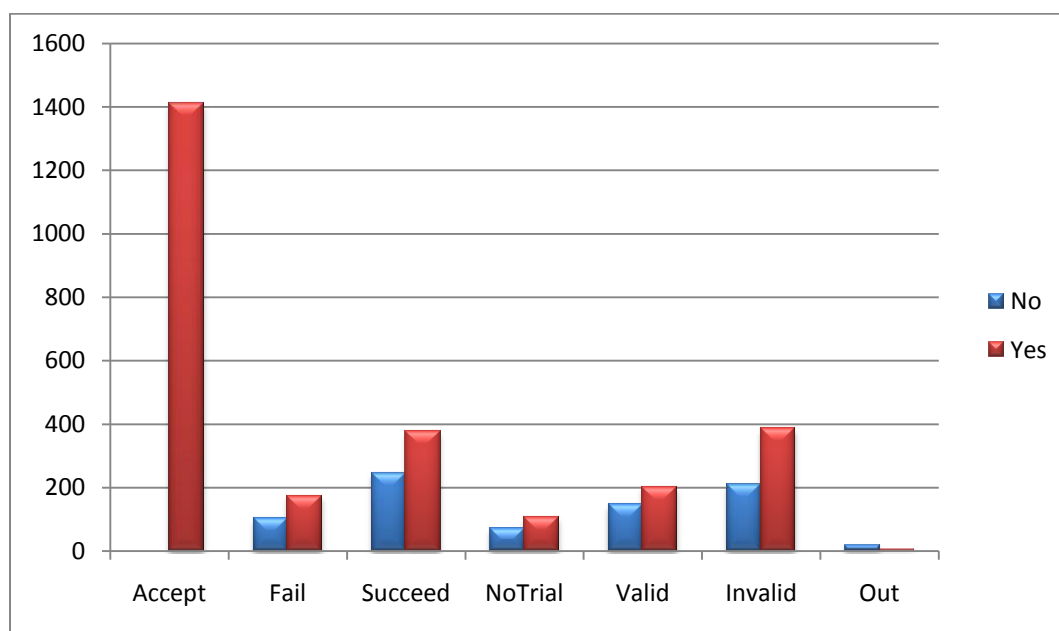
The data showed blank values for team 184 in two rounds in the last 37 rounds of the experiment (rounds 45 and round 54) due to a technical error in the website of the experiment. These blanks were treated as missing values in all the analyses that follow, resulting in the use of 3454 rather than 3456 observations. The general distribution of the data is summarized in a 2-way contingency table where all the values are given in percentages (Table 13 in Appendix D).

The data shows that out of 3454 observations, patent licensing was sought in 76.95% of all cases and that a licensing agreement occurred in 40.82% of these cases.

Figure 1 below gives a visual illustration of the distribution of the data over the seven possible outcomes.

The aggregate findings by scenario are provided in Table 14 in Appendix D. Licensing was sought most in scenario E and F under incomplete and asymmetric information with multiple interactions between both players (78.47% and 83.33%, respectively) compared to 75.87% under scenario A, 77.39% under scenario B, 70.45% under scenario C and 76.22% under scenario D. The frequency of reaching a licensing agreement was the highest under scenario F (48.26%). The highest frequency of challenging a patent occurred under scenario A (40.28%) followed directly by scenario E (38.19%) and the highest frequency of invoking a litigation trial occurred under these same scenarios.

Figure 1: Distribution of licensing decision according to the different outcomes



6.4.2. Statistical analysis

The objectives of the experiment is to investigate the effect of patent breadth, the type of potential entrant and the market conditions on the licensing, patent challenge and litigation decisions. Each decision is analyzed separately and approached differently.

First we examine the innovator's licensing decision using the logistic random effects model (refer to equations 1 and 2) due to the binary nature of the response variable (license). Only data from scenarios A, C and E are used for this analysis since it is only under these scenarios that the innovator initiates licensing.

The decisions of reaching a licensing agreement and challenging a patent by infringement are then examined. The result of each round can yield seven possible outcomes (Accept, Stay Out, Succeed, Fail, No trial, Valid and Invalid) that can be grouped into four main categories: Accept, Stay out, Invest in R&D and Infringe the Patent. Because of the categorical nature of the dependent variables, the best way to examine the decisions of accepting a licensing contract and infringing a patent is using a specific type of multinomial logit regression model, the baseline-category logit model, which estimates the odds of being in one category relative to being in another category for all pairs of categories. However, due to the presence of random effects in the model (explained in subsection 6.4.3), the model failed to converge and we turned to the second best option: transform each category into a binary variable and use the logistic regression model with random effects. Because the only way to reach a licensing agreement is for the innovator to make the decision to license, if she is the initiator (scenarios A, C and E), and for the entrant to make the decision of buying a license, if he is the initiator

(scenarios B, D and F), observations that correspond solely to the license column=yes are kept in the model. On the other hand, all observations from all scenarios are used in examining the decision to challenge the patent via infringement.

Finally, the innovator's decision to litigate is examined. Similar to the previous decision, the logistic regression model with random effect is used due to the binary nature of the dependent variable (i.e., invoke a trial or not). Because the only way to invoke a litigation trial is for the potential entrant to challenge the patent, observations that correspond solely to the results column="Trial" and "NoTrial" are kept in the model.

Each decision is examined first separately under each scenario, where only one market condition varies, and second aggregately using the combined data from all scenarios to allow a better comparison between scenarios.

The analysis of all previously mentioned models is performed using the GLIMMIX procedure in SAS 9.2 ©. This procedure allows fitting generalized linear mixed models and estimates the parameters by applying pseudo-likelihood techniques when the models contain random effect. The binary distribution and the logit link options in GLIMMIX are used. All results are reported at the 0.05 rejection level. All frequency tables are obtained using the FREQ procedure in SAS 9.2 ©.

6.4.3. Data edits

In order to examine the decisions mentioned in subsection 6.4.2., the following data variables are considered for the statistical analysis of all decisions:

- Team, representing the 48 different innovator-entrant pairs.
- Round, representing the round numbers.

- License, representing the innovator's decision to license ("Yes") or not to license ("No").

Because the data collected does not contain explicitly the type of patent breadth or the type of the potential entrant, additional variables capturing these differences were created for each round. These variables are as follows:

- A variable named "Breadth" with two levels, broad and narrow
- A variable named "Type" depicting the three types of potential entrant: same, weak and strong.
- A variable named "Scenario" with three levels reflecting the three scenarios used in this analysis: A, C and E. This variable allowed examining the effect of the market conditions on the licensing decision.
- A variable named "Order" with two levels reflecting the order in which the information was given to the subjects: control and random.
- A variable named "Role" with two levels, first and second, to examine the effect of the role switch on the results. This variable also allowed specifying the effect of the different degree of patent breadth (very broad versus less broad and very narrow versus less narrow) on the licensing decision.

The variables breadth, type, scenario, role and order are treated as fixed effects. Since more than one measurement is taken from each team and considering that we sampled a subset of the entire population of subjects, the variables team and team*role are treated as random effects. All interaction levels of the fixed effects are considered in each model.

6.5. Analysis and results of the patent licensing decision

6.5.1. Data description

As mentioned earlier, one of the objectives of the experiment is to examine the effect of the patent breadth and the type of potential entrant on the licensing behavior of the innovator. To examine this objective, only data from scenarios A, C and E are used for this analysis since it is only under these scenarios that the innovator initiates licensing.

The variables used in this analysis are: Team, License (dependent variable), Breadth, Type, Scenario (in the aggregate analysis), Order and Role.

A total of 1728 records were extracted from the experiment 1727 of which were used in the analysis due to a missing value in round 54. From the 1728 observations, 1294 corresponded to a “Yes” for the dependent variable “**license**” and 433 corresponded to a “No”.

Table 15 summarizes the licensing decision in the relevant scenarios (A, C and E) according to patent breadth and controlling for the type of potential entrant. Table 15 shows a very similar occurrence of licensing when the innovator faces a weak and a strong rival (76.04% and 76.35%, respectively) and a small decrease in the occurrence of licensing when she faces a rival of the same type (72.40%). The occurrence of licensing under both a narrow and a broad patent was similar across all entrant types. Figure 2 illustrates the distribution of licensing by scenario, breadth, type and order controlling for the **role** variable.

Figure 2a shows a similarity in the frequencies of licensing between scenarios A and E compared to a lower frequency for scenario C. Within each scenario, there is a

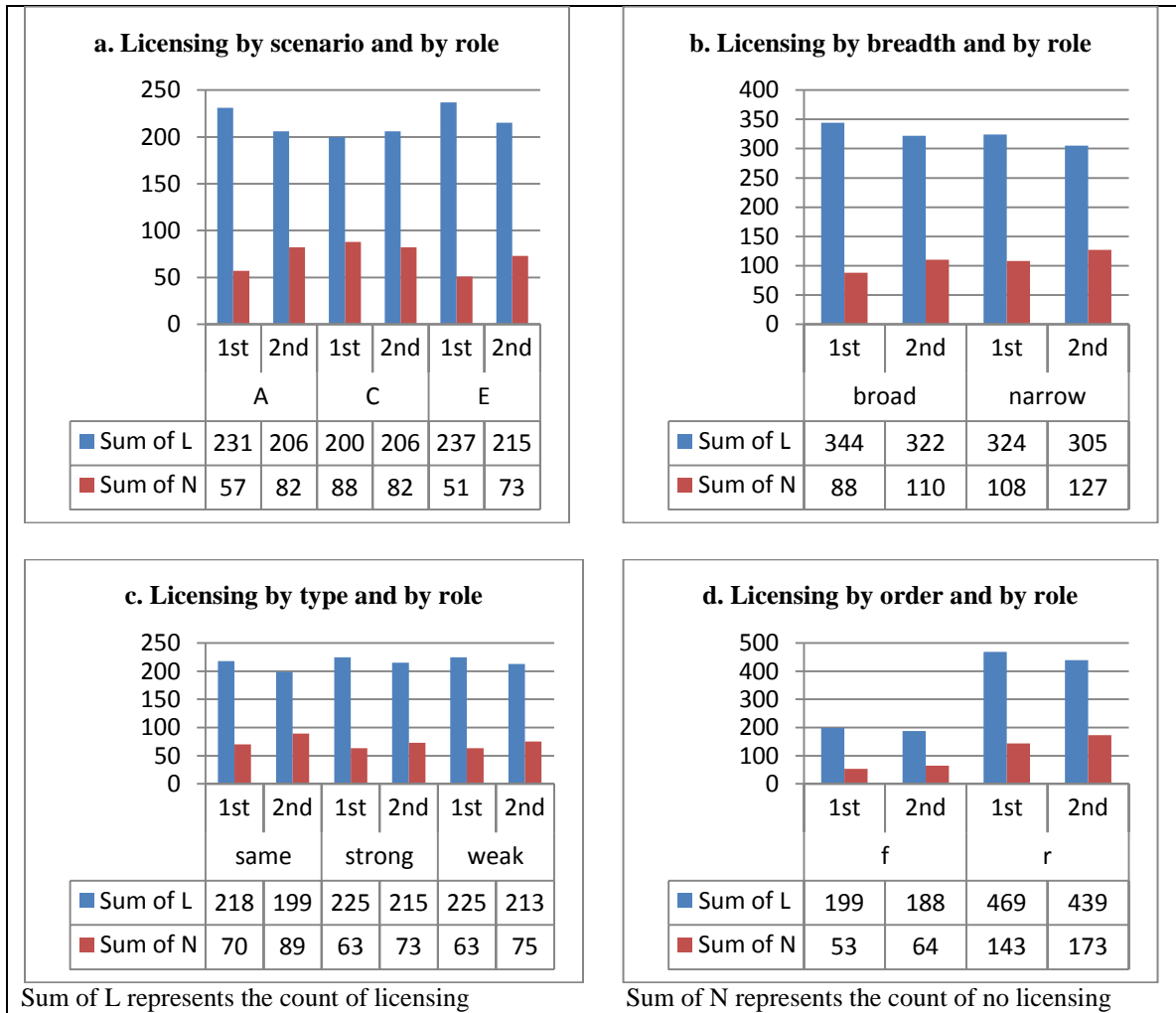
small difference in the frequencies of licensing between the two parts in scenarios A and E but no difference in scenario C.

Figure 2b illustrates the frequency of licensing depending on patent breadth, controlling for role and shows that for both types of breadth, the frequencies of licensing decreased after the subjects switched role, with the frequency of licensing being greater when the innovator held a broad patent versus a narrow patent in both parts.

Figure 2c illustrates the difference in the frequencies of licensing between the three types of potential entrants, controlling for the variable role and shows that the occurrence of licensing decreased after the players switched role regardless of the type of potential entrant and that the frequencies are similar across all types.

Figure 2d compares the licensing decision of the subjects in the control group and those in the treatment group. Similarly to the three previous figures, it shows a decrease in the occurrence of licensing in the last 36 rounds of the experiment. It also shows a greater frequency of licensing in the treatment group. This can be attributed to a larger sample in the treatment group (68 subjects compared to 28 subjects in the control group).

Figure 2: Distribution of licensing by scenario, breadth, type and order controlling for role



Tables 16 and 17 in Appendix D summarize the frequency of licensing by breadth and by type, respectively. The data from Table 16 shows that the frequency of making a licensing offer is higher when the patent is broad versus narrow under complete and symmetric information (scenarios A and C), regardless of the number of interactions between both players (one shot game versus multiple interactions) while the frequency is lower under incomplete and asymmetric information (scenario E).

On the other hand, Table 17 shows that the frequency of making a licensing offer is greater when the innovator faces a potential entrant of lower cost structure (strong rival) under complete and symmetric information (scenario A and C), while under incomplete and asymmetric information (scenario E), the frequency of making a licensing offer is greater when the innovator faces a weak rival. It is also observed that the frequency of making a licensing offer when the innovator faces a strong competitor is very close between all three scenarios (25.69%, 25.39% and 25.17% for scenarios A, C and E, respectively).

6.5.2. Results

The GLIMMIX procedure was used to model the probabilities of licensing.

i. Analysis by scenario:

The decision is first analyzed by scenario and the results are reported in Tables 18 and 19 in Appendix D. For each scenario, all two-way and three-way interactions are included in the model, however none is found significant in all three scenarios.

The results show that the type of the potential entrant and the order of information given do not have any significant effect on the innovator's licensing decision. Only the variables Role and Breadth are found to have a significant effect on the decision of interest in scenario A and no significant effect in scenarios C and E. Table 18 summarizes the results of the type III tests of fixed effects for all three scenarios. The least square means estimates and differences for the variables Order and Breadth are reported in Table 19. The results show that the innovator is more likely to license a broad patent versus a narrow patent; the estimated probabilities being 83.83% and 74.62%, respectively. The

estimated odds of licensing are 1.763 times greater when the patent is broad than when it is narrow. In addition, it is found that innovators are more likely to license when they haven't had any role switch; the estimated probabilities being 83.67% versus 74.84%. The estimated odds of licensing are 1.722 times greater before a role switch than after. However, this effect cannot be attributed solely to the role switch since patent breadth has been reduced in the second part of the experiment.

ii. Analysis of the aggregate data:

The decision is examined then using the combined data from all three scenarios (A, C and E).

All different interactions have been considered in the analysis. All three-way interactions and above were not significant at the 0.05 rejection level, therefore they were removed from the model as the model building process requests. The model was then run including all two-way interactions.

Table 20 summarizes the results of the type III tests of fixed effects and shows that only scenario*role and scenario*type interactions are significant (p-values=0.0185 and 0.0456, respectively) while the breadth and the order are not involved in any significant interactions. Looking at the main effects of breadth and order, we notice that the order variable is not significant (p-value= 0.6662), indicating that the order of information given to the subjects does not have any effect on the licensing decision. On the other hand, the breadth variable had a significant effect (p-value=0.0296).

The reduced model including only the variables that were found to be significant is used then to provide Least Squares Means estimates of the effects of the variables on the licensing decision. The estimated model is the following:

$$\text{logit} \left(\frac{\hat{p}(\text{license}=\text{yes})}{1-\hat{p}(\text{license}=\text{yes})} \right) = \mu + \text{breadth} + \text{type} + \text{scenario} + \text{role} + \text{scenario} * \text{type} + \text{scenario} * \text{role} + \text{team} + \text{team} * \text{role} + \varepsilon \quad (7)$$

The fit of the model is deemed adequate because of the generalized chi squares over the degree of freedom of 0.78 which is close to the recommended value of 1 for the generalized linear models.

Because the **breadth** variable is not involved in any significant interaction, the main effect of that variable is examined, averaged over the remaining interactions. From the least squares means we notice that an innovator is more likely to license her innovation when holding a broad patent than when holding a narrow patent. The estimated probabilities of licensing are 83.34% and 78.77% for broad and narrow breadth, respectively (Table 21a in Appendix D). The estimated odds of licensing are 1.349 times greater when the patent is broad than when the patent is narrow (Table 21b in Appendix D).

Because the remaining variables are involved in two-way interactions, we are only able to examine the simple effects for these variables averaged over breadth and not the main effects. This is performed by looking at the effect of one variable while holding the other one fixed. The “slicediff” option in GLIMMIX procedure is used to test one factor at each level of the other. Tables 22 and 23 in Appendix D report the slice effects comparisons of scenario*role and scenario*type, respectively. These comparisons allow detection of significant differences at specific levels of the interactions. Least squares

means estimates for each scenario*role and scenario*type interactions are given in Table 24 in Appendix D where the estimate column is the estimated effect of the interaction under the logit scale and the mean column is the estimated probability of licensing under a given interaction at the observed scale.

Table 22a in Appendix D reports the simple effect comparisons of scenario*role when controlling for the variable role. The results show a significant difference between the effects of scenarios A and C and scenarios C and E on the licensing decision in the first part of the experiment with extreme degrees of breadth ($p\text{-values} < 0.05$). However, no significant difference in the licensing decision was detected between all three scenarios after the switch occurs and when the patent breadth has been reduced. This absence of difference might be attributed to the learning behavior of the subjects during the experiment and the rounds as well as their rival and/or to the change in the degree of patent breadth (less broad and less narrow). The estimated odds of licensing are 2.107 times greater in the first part when there is a take-it or leave it offer than when there are multiple interactions among the innovator and the potential entrant under complete and symmetric information. Similarly, the estimated odds of licensing when multiple interactions are possible are 2.558 times greater in the first part of the experiment under incomplete and asymmetric information than under complete and symmetric information.

Table 22b in Appendix D reports the simple effect comparisons of scenario*role when controlling for the variable scenario. The results show that there is no significant difference in the effect of licensing between both parts within each scenario. The

licensing decision is independent of the degree of patent breadth and the switch of roles given a scenario.

Table 23a in Appendix D reports the simple effect comparisons of scenario*type when controlling for the variable type. The results show that when the innovator is facing a rival of similar cost structure, there is a significant difference between the effects of scenarios A and C and scenarios C and E. The estimated odds of licensing under complete and symmetric information are 1.671 times greater when only one offer can be made versus the situation where repeated bargaining is possible given that both innovator and entrant have the same cost structure. Similarly, the estimated odds of licensing when repeated bargaining is possible are 1.859 times greater under incomplete and asymmetric information versus complete and symmetric information given that both the innovator and the entrant have the same cost structure. The results also show that the effects of the market conditions on the licensing decision are not significant when the innovator is facing a stronger rival ($p\text{-values} > 0.05$). However, the market conditions have a significant effect on the licensing decision when the innovator is facing a weak rival. Given that the potential entrant has a higher cost structure than the innovator, the estimated odds of licensing under complete and symmetric information are 1.696 times greater when only one offer can be made versus the situation where repeated bargaining is possible; 3.164 times greater under incomplete and asymmetric versus complete and symmetric information when repeated bargaining is possible; and 1.866 times greater under scenario E than under scenario A. However, in this last case, we cannot be certain

whether the possibility of repeated bargaining or the completeness and symmetry of information or both generated the difference between scenarios A and E.

Table 23b in Appendix D reports the simple effect comparisons of scenario*type when controlling for the variable scenario. The results show that under complete and symmetric information, the type of the potential entrant doesn't have a significant effect on the licensing decision when only one offer can be made (scenario A) while it does when repeated bargaining is possible. The estimated odds of licensing under complete and symmetric information and when repeated bargaining is possible are 1.883 times greater when the rival is strong than when the rival is of the same cost structure and 1.716 times greater when the rival is strong than when the rival is weak. Finally, when repeated bargaining is possible under incomplete and asymmetric information, the results show a significant effect of the type of entrant on the licensing decision: The estimated odds of licensing are 1.869 times greater when the innovator faces a weak potential entrant than when she faces a potential entrant of the same cost structure and 1.938 times greater when she faces a weak versus a strong potential entrant.

6.6. Analysis and results of the occurrence of a licensing agreement

6.6.1. Data description

The following analysis examines the effects of patent breadth, the potential entrant's type and the market conditions on the occurrence of a licensing agreement. Unlike the previous analysis, data of all scenarios (A, B, C, D, E and F) are used. However, because the only way to reach a licensing agreement is for the innovator to make the decision to

offer a license if she is the initiator (scenarios A, C and E) and for the entrant to make the decision to seek a license if he is the initiator (scenarios B, D and F), observations that correspond solely to license="yes" are kept in the model, reducing therefore the number of observation used in the analysis from 3454 to 2658. Out of the 2658 licensing offers, 1410 offers were accepted (53.05%) and 1248 offers were rejected (46.95%).

The same variables used in the licensing decision are considered for the statistical analysis. In addition, the "Result" column containing the 7 different possible outcomes (Accept, Stay out, Succeed, Fail, No trial, Valid and Invalid) is used. Since we are only interested in the outcome of accepting the licensing offer at this stage, the multinomial variable Result is transformed into a binary variable where the outcome "Accept" is considered as 1 and all other outcomes are considered as 0.

Table 25 in Appendix D shows that the occurrence of licensing is greater when the potential entrant is the one initiating the licensing process and multiple interactions are possible between both players (scenarios D and F). However, it is slightly higher under incomplete and asymmetric information than under complete and symmetric information (10.46% and 10.12%, respectively).

Tables 26 and 27 in Appendix D summarize the decision of accepting a licensing offer for each level of patent breadth and each level of the type of the potential entrant under different market conditions (scenarios), respectively. The frequency of licensing occurrence given a specific patent breadth depends on the market conditions: In scenarios A and E the frequency is higher when the patent is narrow while the remaining scenarios exhibit the opposite result. The frequency of reaching a licensing agreement is higher

when the innovator is the one initiating the licensing process and when she is facing a strong rival than when she is facing a weak rival (scenarios A, C and E). The opposite is not always true for the remaining scenarios.

The option “chisq” in the Frequency procedure reports the chi-square test for independence for each frequency table. A preliminary look at these chi-squares in Table 26 in Appendix D show that there is a significant difference between the effects of the broad patent and the narrow patent on accepting a licensing offer within scenarios A and B only (p-values=0.0015 and 0.0183, respectively). However, because these frequency tables do not take into account all the variables in the model, the tests are used only to give a description of the data but cannot be relied upon.

In addition, a preliminary look at the chi-square test for each of the 6 frequency tables in Table 27 in Appendix D shows that there is a significant difference between the effects of the type of the potential entrant on accepting a licensing offer only under scenario E (p-value=0.0233). As mentioned earlier, these tests give us a preliminary view of the data but cannot be relied upon due to possible interactions with other variables in the model.

6.6.2. Results

The GLIMMIX procedure was used to model the probabilities that $\text{accept}=1$.

i. Analysis of licensing occurrence by scenario:

The decision is first analyzed by scenario and the results are reported in Appendix D. For each scenario, all two-way and three-way interactions are included in the model.

The results show that in scenario A, none of the three-way and two-way interactions are significant. The occurrence of licensing is significantly affected by the patent breadth and the role variable. The innovator and the potential entrant are more likely to reach a licensing agreement when the patent is narrow versus broad under complete and symmetric information with no multiple interactions regardless of the type of the potential entrant and the order of information given. The estimated probabilities of reaching a licensing agreement are 35% with a broad patent compared to 52.13% with a narrow patent. However, the effect of a narrow patent is not significant on the decision of interest ($p\text{-value}=0.6345$). The estimated odds of licensing occurrence are 2.02 times greater when the patent is narrow than when it is broad. On the other hand, the likelihood of reaching a licensing agreement is higher after the role switch. The estimated probabilities are 34.53% and 52.65% before and after the role switch, respectively. The estimated odds of licensing occurrence are 2.11 times greater after the role switch than before regardless of the type of potential entrant, patent breadth and the order information is provided. This can be explained by the learning behavior of the players (Table 28).

Similar to scenario A, all three-way and two-interactions are not significant in scenario B. The variables that significantly affect licensing occurrence are the patent breadth and the order of information ($p\text{-values}= 0.0167$ and 0.0346 , respectively); the potential entrant's type and the role are not having any significant effect. Unlike the scenario where the innovator initiates the licensing process under complete and symmetric information, in this scenario the likelihood of reaching a licensing agreement is higher when a patent is broad versus narrow. The estimated probabilities are 56.98%

and 45.02% with a broad and narrow patent, respectively. The least squares means estimates of each patent breadth do not have a significant effect on the decision of interest, however their difference does: The odds of licensing occurrence when the entrant is the one initiating the licensing process with no multiple interactions and under complete and symmetric information are 1.62 times greater when a patent is broad than when it is narrow. The order of information affects significantly the decision of interest only when the information is randomized (p-value=0.0293) with an estimated probability of 58.45% compared to 43.55% when the order is fixed. The estimated odds of licensing occurrence are 1.82 times greater when the information is given randomly versus sequentially (Table 29).

In the analysis of the data of scenario C, two three way interactions are found statistically significant: role*breadth*type and order*breadth*type with p-values of 0.0138 and 0.0449, respectively. However, when we estimate the least square means relative to these interactions and investigate the simple effects of each using the “slicediff” option in the “lsmeans” statement in SAS 9.2 ©, we find that only one out of 12 least square means (LSM) estimates and three simple effects out of 25 are significant in the first three-way interaction (Table 30). The same is observed in the second three-way interaction, in which 3 out of 12 LSM estimates and 3 out of 24 simple effects are found significant (Table 31). Therefore the three way interaction is dropped from the model and a second model is fit with all two-way interactions that are found to be not significant. After fitting a third model with no interaction terms, none of the variables are found to affect significantly the licensing occurrence (all p-values are greater than the

0.05 rejection level). This result is also obtained in scenarios D and F. Table 32 summarizes the type III tests of fixed effects for these three scenarios.

In scenario E, when the innovator initiates the licensing process under incomplete and asymmetric information with multiple interactions between both parties, Order*Breadth and Type are found significant. However, when fitting the model with the significant terms, the two-way interaction turned out to be non-significant at the 0.05 rejection level with a p-value of 0.053. Therefore, the only variable affecting the licensing occurrence is the type of potential entrant. Even though the main effect of Type is significant (p-value=0.0392), the LSM estimates for each type are not statistically different from zero at the 0.05 rejection level (Table 33). In addition, only the difference between strong and weak rivals is significant: the odds of licensing occurrence are 1.817 times greater when the innovator faces a strong rival than when she faces a weak rival under incomplete and asymmetric information with multiple interactions and when the innovator is the one initiating the licensing process.

ii. Analysis of the aggregate data:

In the aggregate model, up to 4-way interactions are considered in the analysis. All three-way interactions and above are not significant at the 0.05 rejection level. Therefore, they are removed from the model and the model is run with all two-way interactions.

Table 34 summarizes the results of the type III tests of fixed effects and shows that only Scenario*Role, Scenario*Breadth and Scenario*Type interactions are significant (p-values<0.05). The variable Order is not involved in any interaction and its main effect is not significant, therefore it is removed from the model.

After fitting the significant interactions and relevant terms in the model, Scenario*Type turns out to be non-significant at the 0.05 rejection level with a p-value of 0.0665, hence it is removed from the model. The final fitted model is as follow:

$$\text{logit}\left(\frac{\hat{p}(\text{accept})}{1-\hat{p}(\text{accept})}\right) = \mu + \text{scenario} + \text{role} + \text{breadth} + \text{scenario} * \text{role} + \text{scenario} * \text{breadth} + \varepsilon \quad (8)$$

The fit of the model is deemed adequate because of the generalized chi squares over the degree of freedom of 0.96 which is close to the recommended value of 1 for the generalized linear models.

Because all the variables in the model are involved in two-way interactions, we cannot look at their main effects but their simple effects using the “slicediff” option in the “lsmeans” statement in GLIMMIX procedure. Table 35 reports the slice effects comparisons of Scenario*Breadth sliced by Scenario and by Breadth while Table 36 reports the slice effects comparisons of Scenario*Role sliced by Scenario and by Role. Least squares means estimates for each Scenario*Role and Scenario*Breadth interactions are given in Table 37 where the estimate column is the estimated effect of the interaction under the logit scale and the mean column is the estimated probability of accepting a licensing offer under a given interaction at the observed scale.

The results from Table 35a show a significant difference between the effects of the two levels of patent breadth on the decision to accept a licensing offer within scenarios A and B only, as seen earlier in the data description section. Under complete and symmetric information with no repeated bargaining allowed, the estimated odds of accepting a licensing offer made by the innovator are 2.037 times greater when the patent

in question is narrow rather than broad. On the other hand, under complete and symmetric information with no bargaining allowed, the estimated odds of accepting a licensing offer made by a potential entrant are 1.689 times greater when the patent is broad rather than narrow. This result is conforming to the expectations. When making her decision, the innovator knows that if her patent is challenged, she has a higher probability of finding her patent invalidated or narrowed.

The results from Table 35b show that when the patent is narrow, the different market conditions do not have a significant effect on the decision to accept a licensing offer. However, with a broad patent:

- The party seeking licensing has a significant effect on the decision to accept a licensing offer under complete and symmetric information with no possibility of bargaining (scenarios A and B with $p\text{-value} < 0.0001$) and under incomplete and asymmetric information with the possibility of bargaining (scenarios E and F with $p\text{-value} < 0.0001$), but no effect under complete and symmetric information with bargaining (scenarios C and D).
 - The estimated odds of accepting a licensing offer are 2.857 times greater when the potential entrant is the one approaching the innovator with a licensing offer than when the innovator is initiating, under complete and symmetric information and when repeated bargaining is not possible.
 - The estimated odds of accepting a licensing offer are 2.222 times greater when the potential entrant is the one approaching the innovator with a

licensing offer than when the innovator is initiating, under incomplete and asymmetric information and when repeated bargaining is possible.

- When there is complete and symmetric information, the possibility of repeated bargaining has a significant effect on the decision in question when the innovator is the one approaching the potential entrant (scenarios A and C with $p\text{-value} < 0.0001$), but no significant effect when the potential entrant is the one approaching the innovator for licensing (scenarios B and D). The estimated odds of accepting a licensing offer are 2.352 times greater when bargaining is possible than when bargaining is not possible under complete and symmetric information given that the innovator is the one approaching the potential entrant.
- When bargaining is allowed, the completeness and symmetry of information has a significant effect on the decision in question when the innovator is the one initiating the process with a $p\text{-value} = 0.0023$ (scenarios C and E), but no effect when the potential entrant is the one approaching the innovator with a licensing offer (scenarios D and F). The estimated odds of accepting a licensing offer are 1.880 times greater when there is complete and symmetric information versus incomplete and asymmetric information provided the innovator is the initiator.
- Other significant effects are found in the table (scenarios A and D, scenarios A and F, scenarios B and E, scenarios and scenarios D and E). These effects cannot be explained by this model because more than one characteristics are different among each pair of scenarios. These simple effects are explained by a different

model, where the scenario variable will be broken into three different attributes (information, bargain and initiate).

Table 36a shows that the switch of roles halfway through the experiment and the decrease in the degree of breadth have a significant different effect on the decision to accept a licensing offer within scenario A solely ($p\text{-value}=0.0037$). The estimated odds of accepting a licensing offer are 2.227 times greater when the role switch and the degree of breadth is reduced than before the switch with extreme degree of patent breadth. This effect cannot be explained by this model because there is no way to know what generated the difference: a less narrow or less broad patent and/or the learning behavior developed by the player regarding the experiment and their partner.

Table 36b shows that when the degree of patent breadth is extreme and when there was no previous switch of role between the two parties:

- There is a significant difference between who initiates the licensing process on the decision of accepting the licensing offer under complete and symmetric information when bargaining is not possible (scenarios A and B with $p\text{-value}<0.0001$) and when bargaining is possible (scenarios C and D with $p\text{-value}=0.0090$) and under incomplete and asymmetric information with possible bargaining (scenarios E and F with $p\text{-value}<0.0001$). These significant effects disappear when the degree of patent breadth is reduced and the players switch roles.
 - The estimated odds of accepting a licensing offer before the role switch are 2.882 times greater when the potential entrant initiates than when the

innovator initiates under complete and symmetric information given that repeated bargaining is not possible.

- The estimated odds of accepting a licensing offer before the role switch are 1.782 times greater when the potential entrant initiates than when the innovator initiates under complete and symmetric information given that repeated bargaining is possible.
- The estimated odds of accepting a licensing offer before the role switch are 2.299 times greater when the potential entrant initiates than when the innovator initiates under incomplete and asymmetric information given that repeated bargaining is possible.
- There is a significant difference between repeated bargaining and take it or leave it offers solely when the innovator is the one initiating the licensing process under complete and symmetric information (scenarios A and C with $p\text{-value}=0.0010$). The estimated odds of accepting a licensing offer are two times greater when repeated bargaining is possible than when it is not possible given that the innovator approaches the potential entrant with an offer. No significant effect of repeated bargaining is detected when the potential entrant is the one initiating the licensing process. This effect also disappears after the role switch.
- There is no significant difference between the completeness and symmetry of information and the incompleteness and asymmetry of information when repeated bargaining is possible, but there is between scenarios A and E when repeated bargaining is not possible versus possible given that the innovator is the initiators

(scenarios A and E with $p\text{-value}=0.0275$). This effect also disappears after the role switch. The estimated odds of accepting a licensing offer is 1.56 times greater when the information is incomplete and asymmetric and repeated bargaining is possible than when the information is complete and symmetric and repeated bargaining is not possible, given that the innovator initiates in the first 36 rounds of the experiment. It is very clear that this effect can be attributed to either the nature of information or the possibility of repeated bargaining or both. The second model might be more adequate to explain that effect.

- All other significant effects cannot be explained by this model since more than one characteristic changes between two scenarios.

When the roles switch and the degree of patent breadth is reduced, bargaining has a significant effect on the decision in question under complete and symmetric information given that the potential entrant initiates the licensing process (scenarios B and D with $p\text{-value}=0.0241$). The estimated odds under these conditions are 1.553 times greater when repeated bargaining is possible than when it is not. The other significant effect is between scenarios D and E ($p\text{-value}=0.0274$) but this effect cannot be explained clearly by this model.

6.7. Analysis and results of the patent challenging decision

6.7.1. Data description

The following analysis examines the effects of licensing, patent breadth, the potential entrant's type and the market conditions on an entrant's decision to challenge a patent via infringement. Data of all scenarios (A, B, C, D, E and F) are used.

The variables considered for the statistical analysis are the following: Team, round, license, breadth, type, scenario, order and role, as previously defined. In addition to these variables, the "Result" column containing the 7 different possible outcomes is used. Since we are only interested in the challenging outcome in this analysis, the multinomial variable Result has been first edited as follows: The outcomes corresponding to "Fail" and "Succeed" have been labeled "Invest" and the outcomes corresponding to "Valid", "Invalid" and "No Trial" have been labeled "Challenge" while the other outcomes "Accept" and "Out" stayed the same. Then, a new binary dependent variable, challenge, is created where the outcome "Challenge" is considered as 1 and all other outcomes are considered as 0.

Since challenging a patent can occur whether the decision to license is made or not (but obviously when no agreement to license is reached), all 3454 observations were used, out of which 1120 patent challenges by infringement were noticed (32.43%). From these 1120 patent challenges,

- 61.96% occurred given a licensing offer had been made versus 38.04% when no licensing offer had been made (Table 38a);

- 82.86% occurred when the patent was broad versus 17.14% when the patent was narrow (Table 38c);
- 20.71% occurred under scenario A, 16.34% under scenario B, 16.52% under scenario C, 13.39% under scenario D, 19.64% under scenario E and 13.69% under scenario F (Table 38b);
- 33.48% occurred when the innovator faced a potential entrant of the same cost structure versus 29.38% when she faced a strong potential entrant and 37.14% when she faced a weak potential entrant (Table 38c).

A preliminary look at the chi-squares tests of the 4 frequency tables show that there is a significant difference between the effects of the levels of licensing, breadth, scenario and type on the decision to challenge a patent. However, because these frequency tables do not take into account all the variables in the model, the tests are used only to provide information about the distribution of the data but cannot be relied upon.

6.7.2. Results

The GLIMMIX procedure modeled the probabilities that challenge=1. All results are reported at the 0.05 rejection level in Appendix D.

i. Analysis of patent challenge behavior by scenario

The decision is first analyzed by scenario. For each scenario, all two-way and three-way interactions are included in the model. However, when all three-way interactions are included, the model failed to converge in all scenarios except for scenario A, in which none turned out to be significant.

The analysis of scenario A shows that all two-interactions are not significant and that patent challenge is significantly affected by patent breadth, the type of the potential entrant and whether a licensing offer has been made or not. LSM estimates and differences in these estimates are reported in Table 39. It is found that under complete and symmetric information with no multiple interactions between players, the likelihood of patent challenge is greater when no licensing offer is made by the innovator. The estimated probability of patent challenge is 67.72% when no licensing offer is made versus 25.97% when a licensing offer is made and the estimated odds of infringing a patent are 5.982 times greater when no licensing offer is made than when an offer is made. In addition, the results show that the type of potential entrant affects the challenge behavior when the competitor is weak or strong only. A weak rival is more likely to challenge a patent than a strong rival given the market conditions; the estimated probabilities being 60.48% and 37.62%, respectively. The estimated odds of infringement are 2.54 times greater when the innovator faces a weak rival than when she faces a strong rival. Finally, a broad patent is associated with a higher likelihood of challenge. The estimated probabilities of patent challenge are 78.16% for a broad patent compared to 17.05% for a narrow patent and the estimated odds of challenging a patent by infringement are 17.41 times greater when a patent is broad than when it is narrow.

The results of the analysis of scenario B show that $\text{role} \times \text{license}$, $\text{breadth} \times \text{type}$ and $\text{role} \times \text{breadth}$ have a significant effect on the decision to challenge a patent under complete and symmetric information when the potential entrant is the one initiating the licensing process under a one-shot game. Since all the variables are involved in a two-

way interaction, we can look only at their simple effects (Tables 40 and 41). Similar to scenario A, the likelihood of patent challenge is greater when no licensing offer is made than when an offer is made regardless of the role switch, however, before the role switch, the estimated odds of challenging a patent are 30.97 times greater when no licensing offer is made than when an offer is made compared to 4.62 after a switch in the roles. In addition, no statistical significant pairwise differences between the three levels of type of the potential entrant are detected when the patent is broad. However, there is a significant difference between a strong rival and a weak rival and a rival of equal cost structure to the innovator and a weak rival when the patent is narrow. The estimated odds of patent challenge are 4.41 times greater when the potential entrant is weak than when he is strong, and 3.76 times greater when the potential entrant is weak than when he is of the same cost structure as the innovator. Regardless of the type of the potential entrant, the likelihood of a broad patent being challenged is always greater; however, the estimated odds of challenging a patent given a specific type of potential entrant are 21.22, 38.7 and 6.124 times greater when a patent is broad than when it is narrow given that the potential entrant is of equal, lower and higher cost structure than the innovator, respectively. Finally, the estimated odds of challenging a patent are 61.5 and 4.77 times greater when the patent is broad than when it is narrow before and after a role switch, respectively.

The results of the analysis for scenario C (Tables 42 and 43) show that Breadth, License, Role*Type and Order*Type have a significant effect on the decision of interest. However, when fitting the model using the significant terms, the interaction Order*Type turns out to be not significant (p-value=0.0518) and is dropped from the model. Similar

to previous market conditions, under this scenario, a broad patent is associated with a greater likelihood of infringement. The estimated odds of challenging a patent are 30.56 times greater when a patent is broad than when it is narrow and the estimated probabilities of patent challenge are 71.6% and 7.6% for a broad and narrow patent, respectively. Similarly, it is found that the likelihood of patent challenge is greater when no licensing offer is made than when an offer is made (61.95% and 11.33%, respectively). The estimated odds are 12.75 times greater when no licensing offer is made than when an offer is made. Finally, the results show that there is a statistically significant difference between a strong competitor and a weak competitor and between a weak competitor and a competitor of equal cost structure after a role switch occurs. This might be attributed to the fact that the patent breadth is reduced. In addition, the estimated odds of patent challenge are 3.24 times greater before a role switch (when patent breadth is extreme) than after a role switch (when patent breadth is reduced) given that the type of the entrant is strong while they are 2.49 times greater after than before a role switch given that the type of the entrant is weak.

The results of the analysis of scenario D show that there are no significant two-way interactions and that patent breadth, license and role have a significant effect on the patent challenge behavior. The results are consistent with previous findings: The likelihood of patent challenge is greater with a broad patent and when no licensing offer is made; it is however smaller before a role switch occurs. The estimated probabilities are 54.23% and 9.31% when a licensing offer is made and when it is not, respectively; 63.59% and 6.51% when a patent is broad and narrow, respectively; and finally 20.60%

and 31.93% before and after a switch occurs, respectively. The estimated odds of challenging a patent under complete and symmetric information when the entrant is the one initiating the licensing process with multiple interactions between both parties are 11.54 times greater when no licensing offer is made than when an offer is made, 25.07 times greater when a patent is broad than when it is narrow and finally 1.81 times greater after a role switch occurs than before (Table 44).

In scenario E, license, breadth*type, order*type, role*breadth and order*breadth have been found to have a significant effect on the patent challenge behavior. Tables 45 and 46 report the LSM estimates and the simple effect comparison of the different interactions LSM, respectively. The likelihood of patent challenge is greater when no licensing offer is made. The estimated odds of challenging a patent are 4.37 times greater when the innovator does not make a licensing offer than when she does. Given a narrow patent, the estimated odds of patent challenge are 10 times greater when the rival is weak than when he is strong, however, when the patent is broad, there is no difference between the three types of entrant. The estimated odds of patent challenge are always greater when the patent is broad than when it is narrow for all types of entrant, regardless the order and the role variables. The estimated odds of patent challenge under scenario E are:

- 32.83, 54.61 and 9.271 times greater when the patent is broad than when it is narrow given that the type of entrant is similar to the innovator, strong and weak, respectively;
- 41.5 and 15.7 times greater when the patent is broad than when it is narrow before and after a role switch occurs, respectively;

- 48.34 and 13.48 times greater when the patent is broad than when it is narrow given that the information is given in a fixed sequence and randomly, respectively.

Finally, the patent challenge behavior under scenario F is affected solely by the two-way interaction Breadth*License. The results are reported in Table 47 and show that a broad patent is associated with a greater likelihood of being challenged whether a licensing offer has been made or not by the potential entrant under the market conditions of this scenario. The estimated odds of challenging a patent are 72.24 greater when the patent is broad than when it is narrow given that a licensing offer is not made by the potential entrant versus and 7.75 times greater when the patent is broad than when it is narrow given that a licensing offer is sought by the potential entrant. On the other hand, there is a significant difference between the presence and the absence of a licensing offer when the patent is broad, but no difference at all with a narrow patent. The estimated odds of patent challenge are 11.82 times greater in the absence of a licensing offer than in its presence given that the patent is broad.

ii. Analysis of patent challenge behavior using aggregate data

Up to 3-way interactions are considered in the analysis (all 4-way interaction and above did not converge). The results show a significant 3-way interaction which is kept in the model in addition to all the significant 2-way interactions and the following final model is fitted:

$$\log\left(\frac{\pi}{1-\pi}\right) = \mu + license + breadth + type + scenario + role + order + order * breadth + role * breadth + role * type + breadth * type + breadth * license +$$

$$\begin{aligned} & \text{scenario} * \text{order} + \text{scenario} * \text{type} + \text{order} * \text{type} + \text{scenario} * \text{order} * \text{type} + \\ & \text{team} + \text{team} * \text{role} + \varepsilon \end{aligned} \quad (9)$$

The fit of the model is deemed adequate because of the generalized chi squares over the degree of freedom of 0.89 which is close to the recommended value of 1 for the generalized linear models.

Because all the variables in the model are involved in two-way and/or three-way interactions, we cannot look at their main effects but their simple effects using the “slicediff” option in the “lsmeans” statement in GLIMMIX procedure. The results show a significant effect of:

- The patent breadth regardless of the order in which the games are played (control vs randomized version). The estimated odds of a potential entrant challenging a patent are 39.047 and 23.173 times greater when a patent is broad than when it is narrow under the control and the randomized version, respectively;
- The patent breadth in both parts of the experiment, for all levels of the type of entrant and whether a licensing offer has been made or not. In all these cases, the likelihood of observing a patent challenge is greater with a broad patent regardless of the market conditions. The estimated odds of an entrant challenging a patent are 51.193 and 17.675 times greater when the patent is broad than when it is narrow in the first and second part of the experiment, respectively. The estimated odds in the second part are smaller. This might be due to learning how to play the game (the potential entrant in the second part was the innovator in the first part) and/or to the fact that the degree of patent breadth has been reduced. The

estimated odds of patent challenge are 32.011, 50.608 and 16.802 times greater when a patent is broad than when it is narrow given that the type of entrant is similar to the innovator, strong and weak, respectively. The estimated odds of patent challenge are 51.696 and 17.503 times greater when the patent is broad than when it is narrow given that a licensing offer has been made or not, respectively.

- The role switch when the patent is narrow. The estimated odds of challenging a patent are 2.451 times greater in the second part of the experiment than in the first part of the experiment. This effect can be attributed to the switch in role and/or the reduction in the degree of patent breadth.
- The type of the potential entrant in the second part of the experiment only. The estimated odds of challenging a patent are 1.685 times greater when the entrant is of the equal cost structure to the innovator versus when he is of a lower cost structure; 1.508 times greater when the innovator is facing a weak rival versus a rival of same cost structure; and finally 2.544 times greater when the innovator is facing a weak rival versus a strong rival.
- The role switch when the rival is of a high cost structure. The estimated odds of challenging a patent are 1.934 times greater in the second part of the experiment than in the first part.
- The type of the potential entrant when the patent is narrow. The estimated odds of challenging a patent are 3.18 times greater with a weak rival than with a strong rival; 1.720 times greater when the entrant has an equal cost structure to the

innovator versus a lower cost structure and finally 1.85 times greater when the entrant has a higher cost structure versus a similar cost structure. In addition, a weak rival is more likely to challenge a patent compared to a strong rival under scenarios A, B, C, F in the randomized version and under scenario E in the control version.

- Whether a licensing offer has been made or not. The likelihood of patent challenge is greater when no licensing offer is made for both types of patent breadth, regardless of the market conditions. However, the likelihood is greater when the patent is broad than narrow. The estimated odds are 13.699 and 4.638 times greater in the absence of a licensing offer than in its presence given that the patent is broad and narrow, respectively.
- The number of interaction (one shot game versus multiple interactions game) in both cases: when the innovator is the one initiating the licensing process and when the entrant is the one initiating the licensing process.
 - The likelihood of patent challenge is greater in a one shot game for both the control and the randomized versions given that the innovator is the one initiating the licensing process and the entrant has a high cost structure. It is also greater in the control version and when the entrant has a low cost structure. The estimated odds of challenging a patent are 3.295 and 2.329 times greater in a one-shot game than in a game involving multiple interactions, given that the innovator is the one initiating the licensing process, the entrant has a high cost structure and under the control and the

randomized version, respectively, and 2.6 times greater in a one-shot game than in a repeated interactions game given that the games are played in a random order, the innovator is the one initiating the licensing process and the entrant has a low cost structure.

- The likelihood of patent challenge is greater in a one shot game when the entrant has a high and a low cost structure in the control version.
- The completeness and symmetry of information only when the innovator is the one initiating the licensing process. The estimated odds of challenging a patent are 4.48 and 3.56 times greater under incomplete and asymmetric information than under complete and symmetric information when the entrant is weak in the control version and when the entrant is strong in the randomized version, respectively.
- The party that initiates the licensing process in both types of game (one-shot game and multiple interactions game) under complete and symmetric information and under incomplete and asymmetric information. The likelihood of challenging a patent is higher when the innovator is the one initiating the licensing process in a one shot game under complete and symmetric information in the randomized version and that the type of entrant is same or weak; in a multiple interactions game under complete and symmetric information in the randomized version and the type of entrant is same; and under incomplete and asymmetric information for all types of entrant in the randomized version and for a weak rival in the control version.

6.8. Analysis and results of the litigation decision

6.8.1. Data description

The following analysis examines the effects of licensing, patent breadth, the potential entrant's type and the market conditions on the innovator's decision to invoke an infringement trial. Data of all scenarios (A, B, C, D, E and F) are used.

The variables considered for the statistical analysis are the following: Team, round, license, breadth, type, scenario, order and role, as previously defined. In addition to these variables, the "Result" column containing the 7 different possible outcomes is used. Since we are only interested in the litigation outcome in this analysis, the result multinomial variable has been first edited as follows: The outcomes corresponding to "Valid" and "Invalid" are labeled "Trial" while the outcome "NoTrial" is kept the same. Then, a new binary dependent variable, litigation, is created where the outcome "Trial" is considered as 1 and all other outcomes considered as 0.

Because the only way to invoke a litigation trial is for the potential entrant to challenge the patent via infringement, observations that correspond solely to result column="Trial" and "NoTrial" are kept in the model, reducing therefore the number of observations used in the analysis from 3454 to 1120 out of which 942 resulted in a litigation trial (84.11%).

From these 942 litigation trials,

- 62.31% occurred given a licensing offer had been made versus 37.69% when no licensing offer had been made (Table 48a);

- 21.13% occurred under scenario A, 15.92% under scenario B, 16.77% under scenario C, 13.27% under scenario D, 19.53% under scenario E and 13.38% under scenario F (Table 48b);
- 80.68% occurred when the patent was broad versus 19.32% when the patent was narrow (Table 48c);
- 32.17% occurred when the innovator faced a potential entrant of the same cost structure versus 31.63% when she faced a strong potential entrant and 36.20% when she faced a weak potential entrant (Table 48d).

6.8.2. Results

The GLIMMIX procedure modeled the probabilities that litigation=1. All results are reported at the 0.05 rejection level in Appendix D.

i. Analysis of patent litigation behavior by scenario:

The patent litigation behavior analysis resulted in failure of convergence in some scenarios, therefore the analysis is performed using the combined data and accounting for the effects of the different scenarios.

ii. Analysis of patent litigation behavior using aggregate data:

Up to 3-way interactions are considered in the analysis, however, models including all 3-way and 2-way interactions failed to converge. Therefore, a model with no interactions is fitted.

Type III tests of fixed effects are reported in Table 49. The table shows that the variables order, role, breadth and type have a significant effect on the decision to invoke

a litigation trial while the different market conditions and the licensing decision have no significant effects.

The model is fit again including only the significant terms which turned out to be all significant. The final estimated model is as follow:

$$\log\left(\frac{\pi}{1-\pi}\right) = \mu + breadth + type + role + order + team + team * role + \varepsilon \quad (10)$$

The fit of the model is deemed adequate because of the generalized chi squares over the degree of freedom of 0.68 which is close to the recommended value of 1 for the generalized linear models.

Since all the variables in the model are not involved in any interaction, we are able to look at their main effect. The results are the following (Tables 50 and 51):

- The estimated probabilities of invoking a litigation trial are 96.76% in the control version versus 92.58% in the randomized version. The estimated odds of invoking a litigation trial are 2.393 times greater in the control versus the randomized version;
- The estimated probabilities of invoking a litigation trial are 91.71% before a switch in the roles versus 97.11% after the role switch taking into account that the degree of breadth has been reduced in the second part of the experiment. The estimated odds of invoking an infringement trial are 3.039 times greater in the second part than in the first part of the experiment;
- The estimated probabilities of invoking a litigation trial are 89.29% when the patent is broad versus 97.81% when the patent is narrow. The estimated odds of

invoking a litigation trial are 5.347 times greater when the patent is narrow versus broad;

- The estimated probabilities of invoking a litigation trial are 93.37% when the innovator faces a rival of similar cost structure, versus 97.47% when the entrant has a lower cost structure and 92.98% when the entrant has a higher cost structure.

6.9. Concluding remarks

This chapter discussed an economic interactive experiment developed to investigate the effect of the breadth of patent protection and the cost structure of a potential licensee on an innovator's decision to license her patent and to litigate under infringement as well as on the likelihood of a patent challenge by infringement. These effects are examined under six different market conditions to determine whether these market conditions affect behavior. The market conditions of interest are (i) whether the patentee or the potential entrant initiate the licensing process, (ii) the nature of interaction between the patentee and the entrant during the bargaining process (one shot versus repeated interaction), and (iii) the nature of information available to the patentee and the entrant when they make their respective decisions (complete versus incomplete information). The experiment was run with 96 undergraduate students attending UNL.

The results show that patent breadth has a significant effect on licensing behavior. The findings are consistent with the existing literature in the sense that economic agents are more likely to license a broad patent than a narrow patent regardless of the market conditions and the type of potential entrant they face. Also, the market conditions are

found to have a significant effect on the licensing behavior depending on the type of potential entrant the innovator faces. When the innovator faces a strong rival, the licensing decision is independent of the market conditions. However, when she faces a weak rival or a rival of a similar cost structure, licensing is more likely to be sought in a one-shot game than in a repeated interactions game under complete and symmetric information, regardless of who initiates the licensing process. In addition, licensing is more likely to be sought under incomplete and asymmetric information than under complete and symmetric information regardless of who initiates the licensing process. In the same manner, the type of the potential entrant affects significantly the licensing behavior depending on the market conditions. In a repeated interactions game under complete information, the innovator is more likely to license to a strong competitor versus a competitor of a similar or higher cost structure, while under incomplete and asymmetric information, the innovator is more likely to license to a weak rather than a strong competitor. The order the games are played (control versus randomized version) doesn't have any effect on the licensing decision.

The results also show that the likelihood of licensing occurrence depends on the patent breadth under complete and symmetric information with no repeated interactions. The likelihood of reaching a licensing agreement is greater with a narrow patent when the innovator is the one initiating the licensing process, while it is found to be greater with a broad patent when the entrant is the one initiating the licensing process, regardless of the type of the potential entrant. The latter findings where the entrant is the one seeking a license conform to expectations as the innovator is more likely to accept a licensing offer

when her patent is broad because of the high risk of a patent challenge. However, the results are not expected when the innovator is the one seeking a license since with a narrow patent, one would expect a strong rival to find it optimal to invest in R&D rather than settling to a licensing contract. We also found that the different market conditions have a significant effect on the licensing occurrence when the patent is broad and none when it is narrow. The nature of the potential entrant is only found to be important under incomplete and asymmetric information. Licensing is more likely to occur when the innovator faces a strong rival under incomplete and asymmetric information with repeated interactions given that the innovator is the one initiating the licensing process. The order the games are played does not affect the decision to accept a licensing offer.

The patent challenge behavior is found to be greatly affected by the patent breadth and by whether a licensing offer has been made or not. The results show that a broad patent is more likely to be challenged, by infringement in this experiment, by all types of potential entrant and under all market conditions, which conforms to the predictions of theoretical studies. In addition, the likelihood of patent challenge is greater when no licensing offer has been made under all market conditions and for all types of entrant. The nature of the entrant is found to have a significant effect on the patent challenge behavior: A weak rival is more likely to challenge a patent than a strong rival. The patent challenge behavior is affected also by the different market characteristics (who initiate the licensing process, the completeness of information and the presence or absence of repeated bargaining) depending on the nature of the entrant and the order the games are played.

Finally, the results show that patent litigation behavior is greatly affected by patent breadth, the nature of the entrant, the order the games are played and the role switch. The likelihood of an innovator invoking an infringement trial is greater when she holds a narrow patent (as suggested in patent litigation literature), when she faces a strong rival, under the control version and after a role switch has taken place.

CHAPTER VII

CONCLUSIONS

This study investigated the objective of a patentee when deciding to license her patent by examining whether, when the decision to license is made, the patentee maximizes profits or her strategy is to maintain a dominant market position by controlling the largest market share. The study also investigated the likelihood of patent licensing, licensing occurrence, patent challenge and patent litigation given patent breadth and the type of a potential entrant. Each decision has been examined separately under six different market conditions (scenarios) to identify the effects of the party initiating the licensing process, the possibility of repeated bargaining and the completeness and symmetry of information on the behavior of the economic agents.

The above questions were examined using economics experiments with undergraduate students from UNL as subjects. An individual experiment was developed to investigate the objective from licensing, while an interactive experiment was developed to examine the patent licensing, patent challenge and patent litigation behavior. The findings of these experiments are summarized in sections 5.5 and 6.9 in this study. These findings are very helpful in understanding various aspects of the patent licensing, patent challenging and patent litigation behavior.

Both experiments generated rich data. However, only part of this data was used to investigate the objectives of this study. The use of the complete data will help investigate additional interesting economic questions, such as:

- Possible differences in patenting behavior between subjects exposed and trained to think like economists (students in Economics, Agricultural Economics, Business or any other related major) and subjects without this training;
- The licensing behavior of the potential entrants (scenarios B, D and E) depending on patent breadth and the nature of the potential entrant under the six different market conditions;
- The effect of the agreed upon licensing fee on likelihood of patent challenge and patent litigation as well as on the occurrence of licensing depending on the patent breadth and the nature of the potential entrant under the six different market conditions;
- The effect of patent breadth and the type of potential entrant on the number of offers made in the repeated interactions games.

These economic questions will be examined using the data generated by the second experiment developed in this study. In this experiment, each patent holder was allowed to face one potential licensee at a time and the subjects were paired up randomly and electronically preserving anonymity among subjects. It would be interesting to replicate the current experiment, however, allowing for a direct personal interaction between each pair of patent holder and potential entrant.

Another possible extension of the second experiment would be to allow the innovator to face many potential entrants of different types at the same time and test the theory developed by Rockett (1990) which suggests that the patentee can crowd the market with weak competitors to leave the strong competitors out of the market.

Other extensions would be to allow for a potential entrant to face many innovators and for many innovators to face many potential entrants. However, these variations require a different experimental design than the one developed in this study and will be the focus of future research.

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**APPENDIX A1: ANNOUNCEMENT: ECONOMICS EXPERIMENT IN THE DEPT. OF
AGRICULTURAL ECONOMICS**

You are invited to participate in an economics experiment that will be conducted in the next month at the Department of Agricultural Economics at the University of Nebraska-Lincoln. The experiment seeks to examine how individuals make economic decisions under different situations and will last up to an hour. Your participation will involve making decisions given the information provided to you. Your decisions will be kept confidential and all data collected will be presented in aggregate form so it would be impossible to identify you and/or link you to any given decision. For your participation you will be paid \$15 an amount that exceeds the compensation that you would receive for working a comparable number of hours. Your participation fee will be paid to you in cash immediately after the completion of the experiment.

If you are interested in participating please send the information requested below via email to Dr. Emie Yiannaka at yiannaka2@unl.edu and Ms Rita Abdelnour at ritaen@huskers.unl.edu and use “Economics Experiment” as your email’s subject to ensure we receive your response. Once we receive your email, we will contact you with more information on the time and place where the experiment will be conducted. Thank you.

Your name:

Your major:

Phone (day):

(evening, if different):

Email address:

Please indicate which time/day is most likely to be convenient for you this semester; feel free to indicate more than one time/day

Appendix A2: INFORMED CONSENT FORM (will be read to the participants at the beginning of the session)

Study Title: Using Economic Experiments to Understand Patenting Behavior: The Patent Licensing Decision

You have registered to participate in an economics experiment that seeks to examine how individuals make economic decisions under different situations. The information gathered may help the authors of the study to better understand the patent licensing decision making process. There are no known risks involved in participating in the experiment which will last about an hour. You will receive \$15 in cash at the end of the session as a compensation for your participation. You are free to withdraw at anytime during the session. However, by withdrawing you will rescind your right to get paid.

The information that you provide will be kept confidential and known only to the authors of this study. In addition, all data collected will be presented in aggregate form so it will be impossible to identify you and/or link you to any given decision. During the experiment you will be identified by an identification number assigned to you at the beginning of the experiment.

You may ask questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may call the investigators, office phone, (402) 472-2047 or (402) 472-7865. Please contact the investigators:

- if you want to voice concerns or complaints about the research
- in the event of a research related injury

Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons:

- you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant
- to voice concerns or complaints about the research
- to provide input concerning the research process
- in the event the study staff could not be reached

Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln, department of Agricultural Economics, or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Thank you in advance for your participation in the experiment.

Signature of participant:

Signature of Research Participant

Date

Name and phone number of investigators:

Dr. Amalia (Emie) Yiannaka, PhD, Principal Investigator
Ms. Rita Abdelnour, RA, Co-Investigator

office: (402) 472-2047
office: (402) 472-7865

APPENDIX A3: EXPERIMENT 1: GENERAL INSTRUCTIONS AND SURVEY

General instructions

Welcome! During the following hour you are going to participate in an economics exercise that requires you to make decisions under different situations. Please read every situation carefully as while some situations might seem the same they are different. You may notice other participants in the room that will be part of the same experiment; however, there will be no interaction among you, your decisions will not affect theirs (and vice versa) and your decisions will be unknown to them. Do not be concerned if others make decisions and finish before you. When you are done making all decisions you may leave. Are there any questions?

Scenario 1:

Assume that you are an innovator who has developed a new product, you have patented it and have made the decision to license it. You can license it to one of the following rival firms: a strong competitor or a weak competitor **knowing that the firm that does not receive a license will stay out of the market.**

The strong competitor has lower costs than you, will produce more output than you but will pay you a higher royalty fee than the weak competitor. The weak competitor has higher costs than you, will produce less output than you but will pay you a lower royalty fee than the strong competitor. Under this case, if you license to the weak competitor you maintain your dominant market share position (which means that you will be producing more than your rival) and you will be viewed as the leader in this market while if you license to the strong competitor you lose your dominant market share position (which means that you will be producing less than your rival) and you will no longer be viewed as the market leader. Your total profits (which include production profits and the royalty fee paid to you by the rival firm) when you license to the strong rival may be smaller, greater than or equal to your total profits when you license to the weak rival.

The following 18 rounds describe different situations regarding your market share/leadership position and total profits from licensing to either type of firm. The decision you need to make is to whom you will license under each round given the information you receive; the weak rival or the strong rival. For each round, click on the type of firm you are going to license to and then click the submit button. If you need to read this general description before making a decision under any of the following 18 rounds click on the 'Scenario 1: General Description' button.

Are there any questions?

Round 1:

Your market share from licensing to the strong competitor < your market share from licensing to the weak competitor

And

Your total profits from licensing to the strong competitor = your total profits from licensing to the weak competitor

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 2:	Your market share	85%	50%
	Your total profit	\$150 million	\$150 million

Your decision: A. License to the weak rival

B. License to the strong rival

Round 3:

Your market share from licensing to the strong competitor $<$ Your market share from licensing to the weak competitor

And

Your total profit from licensing to the strong competitor $<$ Your total profit from licensing to the weak competitor

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 4:	Your market share	60%	50%
	Your total profit	\$150 million	\$110 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 5:	Your market share	$1.5 C > 50 \%$	$C < 50 \%$
	Your total profit	$\$1.25 D$	$\$D$

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and a half times greater than your market share when you license to the strong rival and you will control more than 50% of the market. In addition, your total profits will be one and a quarter times greater when you license to the weak than when you license to the strong rival.

Your decision: A. License to the weak rival

B. License to the strong rival

Round 6:

Your market share from licensing to the strong competitor < Your market share from licensing to the weak competitor

Your total profits from licensing to the strong competitor > Your total profits from licensing to the weak competitor

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 7:	Your market share	90%	40%
	Your total profit	\$467 million	\$928 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 8:	Your market share	90%	40%
	Your total profits	\$467 million	\$750 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 9:	Your market share	90%	40%
	Your total profits	\$467 million	\$592 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 10:	Your market share	60%	30%
	Your total profits	\$400 million	\$750 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 11:	Your market share	75%	30%
	Your total profits	\$400 million	\$750 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 12:	Your market share	90%	30%
	Your total profits	\$400 million	\$750 million

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 13:	Your market share	$1.25 C > 50 \%$	$C < 50 \%$
	Your total profits	\$D	\$1.25 D

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and a quarter times greater than your market share when you license to the strong rival and you will

control more than 50% of the market. However, your total profits will be one and a quarter times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 14:	Your market share	$1.25 C > 50 \%$	$C < 50 \%$
	Your total profits	$\$D$	$\$1.5 D$

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and a quarter times greater than your market share when you license to the strong rival and you will control more than 50% of the market. However, your total profits will be one and a half times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 15:	Your market share	$1.25 C > 50 \%$	$C < 50 \%$
	Your total profits	$\$D$	$\$2 D$

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and a quarter times greater than your market share when you license to the strong rival and you will control more than 50% of the market. However, your total profits will be two times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 16:	Your market share	$1.5 C > 50 \%$	$C < 50 \%$
	Your total profits	\$D	\$1.25 D

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and a half times greater than your market share when you license to the strong rival and you will control more than 50% of the market. However, your total profits will be one and a quarter times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 17:	Your market share	$1.75 C > 50\%$	$C < 50 \%$
	Your total profits	\$D	\$1.25 D

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be one and three quarter times greater than your market share when you license to the strong rival and you will control more than 50% of the market. However, your total profits will be one and a quarter times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival

B. License to the strong rival

		When licensing to the weak rival	When licensing to the strong rival
Round 18:	Your market share	$2C > 50\%$	$C < 50\%$
	Your total profits	$\$D$	$\$1.25D$

The parameter C is a percentage while the parameter D is millions of dollars. Thus, under this case if you license to the weak rival your market share will be two times greater than your market share when you license to the strong rival and you will control more than 50% of the market. However, your total profits will be one and a quarter times greater when you license to the strong than when you license to the weak rival.

Your decision: A. License to the weak rival
B. License to the strong rival

Scenario 2

Assume that you are an innovator who has developed a new product, you have patented it and have made the decision to license it. You can license it to one of the following rival firms: a strong competitor or a weak competitor. **However, there is a probability that the firm that does not receive a license will enter the market without a licensing contract.**

The strong competitor has lower costs than you, will produce more output than you but will pay you a higher royalty fee than the weak competitor. The weak competitor has higher costs than you, will produce less output than you but will pay you a lower royalty fee than the strong competitor. Under this case, if you license to the weak competitor you maintain your dominant market share position (which means that you will be producing more than your rival) and you will be viewed as the market leader but your total profits (which include production profits and the royalty fee paid to you by the rival firm) will be lower than if you were to license to the strong competitor. On the other hand, if you license to the strong competitor you lose your dominant market share position (which means that you will be producing less than your rival) and you will no

longer be viewed as the market leader but your total profits are greater than if you were to license to the weak competitor.

In both cases, whether you decide to license to the strong or to the weak competitor, there is a probability that the firm that does not receive a license will enter the market without a licensing contract in which case your market share and total profits will be affected.

The following 11 rounds describe different situations regarding your market share/leadership position and total profits from licensing to either type of firm. The decision you need to make is to whom you will license under each round given the information you receive; the weak rival or the strong rival. For each round, click on the type of firm you are going to license to and then click the submit button. If you need to read this general description before making a decision under any of the following 11 rounds click on the 'Scenario 2: General Description button'.

Are there any questions?

		When licensing to the weak rival	When licensing to the strong rival
Round 1:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

You have decided to license to the weak competitor. Assume that there is a 20% probability that the strong competitor will enter the market without a license in which case your new market share and total profits from licensing to the weak competitor would be:

	When licensing to the weak rival
Your market share	45%
Your total profits	\$ 200 million

Given this new information you may or may not want to change your initial decision.

Please choose one of the following options.

- A. I do not want to change my initial decision, I will license to the weak rival.
- B. I want to change my initial decision, I will license to the strong rival.

You have decided to license to the strong competitor. Assume there is a 20% probability that the weak competitor will enter the market without a license in which case your new market share and total profits from licensing to the strong competitor would be:

	When licensing to the strong rival
Your market share	20%
Your total profits	\$ 475 million

Given this new information you may or may not want to change your initial decision.

Please choose one of the following options.

- A. I do not want to change my initial decision, I will license to the strong rival.
 - B. I want to change my initial decision, I will license to the weak rival.
-
-

		When licensing to the weak rival	When licensing to the strong rival
Round 2:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

You have decided to license to the weak competitor. Assume that there is a 40% probability that the strong competitor will enter the market without a license in which case your new market share and total profits from licensing to the weak competitor would be:

	When licensing to the weak rival
Your market share	45%
Your total profits	\$ 200 million

Given this new information you may or may not want to change your initial decision. Please choose one of the following options.

- A. I do not want to change my initial decision, I will license to the weak rival.
- B. I want to change my initial decision, I will license to the strong rival.

You have decided to license to the strong competitor. Assume there is a 40% probability that the weak competitor will enter the market without a license in which case your new market share and total profits from licensing to the strong competitor would be:

	When licensing to the strong rival
Your market share	20%
Your total profits	\$ 475 million

Given this new information you may or may not want to change your initial decision. Please choose one of the following options.

- A. I do not want to change my initial decision, I will license to the strong rival.
 - B. I want to change my initial decision, I will license to the weak rival.
-
-

		When licensing to the weak rival	When licensing to the strong rival
Round 3:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

You have decided to license to the weak competitor. Assume that there is a 60% probability that the strong competitor will enter the market without a license in which case your new market share and total profits from licensing to the weak competitor would be:

	When licensing to the weak rival
Your market share	45%
Your total profits	\$ 200 million

Given this new information you may or may not want to change your initial decision. Please choose one of the following options.

- A. I do not want to change my initial decision, I will license to the weak rival.
- B. I want to change my initial decision, I will license to the strong rival.

You have decided to license to the strong competitor. Assume there is a 60% probability that the weak competitor will enter the market without a license in which case your new market share and total profits from licensing to the strong competitor would be:

	When licensing to the strong rival
Your market share	20%
Your total profits	\$ 475 million

Given this new information you may or may not want to change your initial decision. Please choose one of the following options.

A. I do not want to change my initial decision, I will license to the strong rival.

B. I want to change my initial decision, I will license to the weak rival.

		When licensing to the weak rival	When licensing to the strong rival
Round 4:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

You have decided to license to the weak competitor. Assume that there is a 80% probability that the strong competitor will enter the market without a license in which case your new market share and total profits from licensing to the weak competitor would be:

	When licensing to the weak rival
Your market share	45%
Your total profits	\$ 200 million

Given this new information you may or may not want to change your initial decision.

Please choose one of the following options.

A. I do not want to change my initial decision, I will license to the weak rival.

B. I want to change my initial decision, I will license to the strong rival.

You have decided to license to the strong competitor. Assume there is a 80% probability that the weak competitor will enter the market without a license in which case your new market share and total profits from licensing to the strong competitor would be:

	When licensing to the strong rival
Your market share	20%
Your total profits	\$ 475 million

Given this new information you may or may not want to change your initial decision.

Please choose one of the following options.

A. I do not want to change my initial decision, I will license to the strong rival.

B. I want to change my initial decision, I will license to the weak rival.

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 5:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 20% probability that the strong rival will enter the market when you license to the weak rival and a 20% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

	When licensing to the weak rival and the strong rival enters with 20% probability	When licensing to the strong rival and the weak rival enters with 20% probability
Your market share	45%	20%
Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 6:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 40% probability that the strong rival will enter the market when you license to the weak rival and a 40% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

		When licensing to the weak rival and the strong rival enters with 40% probability	When licensing to the strong rival and the weak rival enters with 40% probability
Your market share		45%	20%
	Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 7:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 60% probability that the strong rival will enter the market when you license to the weak rival and a 60% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

	When licensing to the weak rival and the strong rival enters with 60% probability	When licensing to the strong rival and the weak rival enters with 60% probability
Your market share	45%	20%
Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 8:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 80% probability that the strong rival will enter the market when you license to the weak rival and a 80% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

	When licensing to the weak rival and the strong rival enters with 80% probability	When licensing to the strong rival and the weak rival enters with 80% probability
Your market share	45%	20%
Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 9:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 40% probability that the strong rival will enter the market when you license to the weak rival and a 20% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

		When licensing to the weak rival and the strong rival enters with 40% probability	When licensing to the strong rival and the weak rival enters with 20% probability
Your market share		45%	20%
	Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 10:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 60% probability that the strong rival will enter the market when you license to the weak rival and a 20% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

	When licensing to the weak rival and the strong rival enters with 60% probability	When licensing to the strong rival and the weak rival enters with 20% probability
Your market share	45%	20%
Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

		When licensing to the weak rival and the strong rival does not enter	When licensing to the strong rival and the weak rival does not enter
Round 11:	Your market share	80%	30%
	Your total profits	\$ 500 million	\$ 650 million

If there is a 80% probability that the strong rival will enter the market when you license to the weak rival and a 20% probability that the weak rival will enter the market when you license to the strong rival in which case your new market share and total profits will be given by

	When licensing to the weak rival and the strong rival enters with 80% probability	When licensing to the strong rival and the weak rival enters with 20% probability
Your market share	45%	20%
Your total profits	\$ 200 million	\$ 475 million

Your decision: A. License to the weak competitor

B. License to the strong competitor

**APPENDIX B1: ANNOUNCEMENT: ECONOMICS EXPERIMENT IN THE DEPT. OF
AGRICULTURAL ECONOMICS**

You are invited to participate in an economics experiment that will be conducted in May 2009 at the Department of Agricultural Economics at the University of Nebraska-Lincoln on East Campus. The experiment seeks to examine how individuals make economic decisions under different situations and will last up to an hour and a half. Your participation will involve making decisions given the information provided to you. During the experiment you are going to be paired up electronically against a person that will be anonymous to you as you will be to them and your decisions will affect their potential earnings and vice versa. Your decisions will be kept confidential and all data collected will be presented in aggregate form so it would be impossible to identify you and/or link you to any given decision. For your participation you will be paid a minimum payment of \$10. This amount will be paid to you at the end of the experiment regardless of how you play the game. However, depending on how you play the game, you could potentially earn up to \$20 **in addition** to your minimum payment, for a total potential payment of \$30. You will be paid in cash immediately after the completion of the experiment.

The experiment will start the first week after final exams week and will be conducted in the "Experimental and Behavioral Economics Laboratory" (EBEL) on East campus, at Filley Hall, room 59, which is located in the basement of Filley Hall.

If you are interested in participating please register in one of the sessions below by replying to our email and mentioning the session that you are registering for. Please also indicate whether any of the remaining sessions could also work for you. Send the information requested to Dr. Emie Yiannaka at yiannaka2@unl.edu and Ms Rita Abdelnour at ritaen@huskers.unl.edu and use "Economics Experiment" as your email's subject to ensure we receive your response. Thank you.

APPENDIX B2: INFORMED CONSENT FORM (will be read to the participants at the beginning of the session)

Study Title: Using Economic Experiments to Understand Licensing Behavior: The Patent Licensing Decision

You have registered to participate in an economics experiment that seeks to examine how individuals make economic decisions under different situations. The information gathered may help the authors of the study to better understand the patent licensing decision making process. There are no known risks involved in participating in the experiment which will last about an hour and a half. For your participation you will be paid a minimum payment of \$10. This amount will be paid to you at the end of the experiment regardless of how you play the game. However, depending on how you play the game, you could potentially earn up to \$20 **in addition** to your minimum payment, for a total potential payment of \$30. You are free to withdraw at anytime during the session. However, by withdrawing you will rescind your right to get paid.

The information that you provide will be kept confidential and known only to the authors of this study. In addition, all data collected will be presented in aggregate form so it will be impossible to identify you and/or link you to any given decision. During the experiment you will be identified by an identification number assigned to you at the beginning of the experiment.

You may ask questions concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may call the investigators, office phone, (402) 472-2047 or (402) 472-7865. Please contact the investigators:

- if you want to voice concerns or complaints about the research
- in the event of a research related injury

Please contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons:

- you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant
- to voice concerns or complaints about the research
- to provide input concerning the research process
- in the event the study staff could not be reached

Participation in this study is voluntary. You can refuse to participate or withdraw at any time without harming your relationship with the researchers or the University of Nebraska-Lincoln, department of Agricultural Economics, or in any other way receive a penalty or loss of benefits to which you are otherwise entitled.

Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

Thank you in advance for your participation in the experiment.

Signature of participant:

Signature of Research Participant

Date

Name and phone number of investigators:

Dr. Amalia (Emie) Yiannaka, PhD, Principal Investigator
Ms. Rita Abdelnour, RA, Co-Investigator

office: (402) 472-2047
office: (402) 472-7865

APPENDIX B3: GENERAL INSTRUCTIONS AND DEMONSTRATION

General instructions

Welcome! During the following hour you are going to participate in a series of rounds that require you to make decisions under different situations. In each round you are going to be paired up electronically against a person that will be anonymous to you as you will be to them. You will be making decisions in a market where one of you will be an innovator who holds a patent on a new product and the other will be a potential entrant (rival) who is considering producing and selling a product in the innovator's market. In some rounds you might be the innovator, while in others you might be the entrant. The decisions you and the person you will be matched up against make affect the payoffs you will both earn. Each of you will earn a **minimum** of \$10 dollars for participating in the experiment; this amount will be paid to you at the end of the experiment regardless of how you play the game. However, depending on how you play the game, you could potentially triple your minimum payment and earn up to \$20 **in addition** to your minimum payment.

Note that, in the market where you will be making your decisions, your payoffs will be measured in millions of dollars. One million dollars corresponds to \$0.02 in real money. Your objective is to maximize your earnings in each round. Please note that depending on your decisions, you may end up losing money. The total amount you earn or lose is the sum of what you earn/lose under each round. If after the completion of all rounds your total payoffs are zero or negative, your *additional* payment will be zero and you will be paid your participation fee (\$10). If, for instance, your total payoff at the end of all rounds is \$450 Million you will be paid an additional \$9 at the end of the experiment while if your total payoff is -\$20M your additional payment will be zero.

Market conditions

Scenario A

The innovator needs to decide whether to sell a patent license to the entrant that will allow him/her to enter the innovator's market.

- If the innovator decides to sell a license, she/he needs to determine the licensing fee that the entrant must pay. If the entrant accepts the offer to obtain a license and pays the licensing fee proposed by the innovator the game ends. The payoffs earned in this case depend on the agreed upon licensing fee.
- If the entrant rejects the licensing offer, or if the innovator decides not to sell a patent license, the entrant need to decide (1) whether to stay out of the market, (2) enter the market and try to produce a product that does not infringe on the innovator's patent or (3) enter the market and legally challenge the patent (i.e., infringe and/or challenge the validity of the patent). Each of the above three decisions results in different payoffs for the innovator and the entrant. In addition, decisions (2) and (3) are associated with certain probabilities that the entrant will be successful in producing a product that does not infringe the patent (decision (2)) and that a patent challenge will result in the patent found invalid in court and thus revoked (decision (3)).
- If the entrant decides to infringe the patent, the innovator needs to further decide whether to invoke an infringement trial or not.

Note that, all these decisions and their associated payoffs need to be considered in order to make a decision.

A game tree that highlights the possible decisions for the innovator and the entrant and the probabilities and payoffs associated with each decision under this scenario will be provided under each round. What will differ from round to round are the payoffs and the probabilities associated with the different outcomes. On the game tree, the innovator's payoffs appear next to the letter I while the entrant's payoffs next to the letter E. your own payoffs will appear in bold to distinguish them from your rival's payoffs.

Under this scenario, both you and the person you are matched up against have access to the same game tree, probabilities and payoff information.

Scenario B

The market conditions under scenario B are similar to those under scenario A. The only difference between the two scenarios is that under scenario B it is the entrant that seeks a patent license and makes a licensing offer to the innovator.

Scenario C

The market conditions under scenario C are similar to those under scenario A. The only difference between the two scenarios is that under scenario C there may be multiple interactions between the innovator and the entrant when determining the licensing fee.

Scenario D

The market conditions under scenario D are similar to those under scenario B. The only difference between the two scenarios is that under scenario D there may be multiple interactions between the innovator and the entrant when determining the licensing fee.

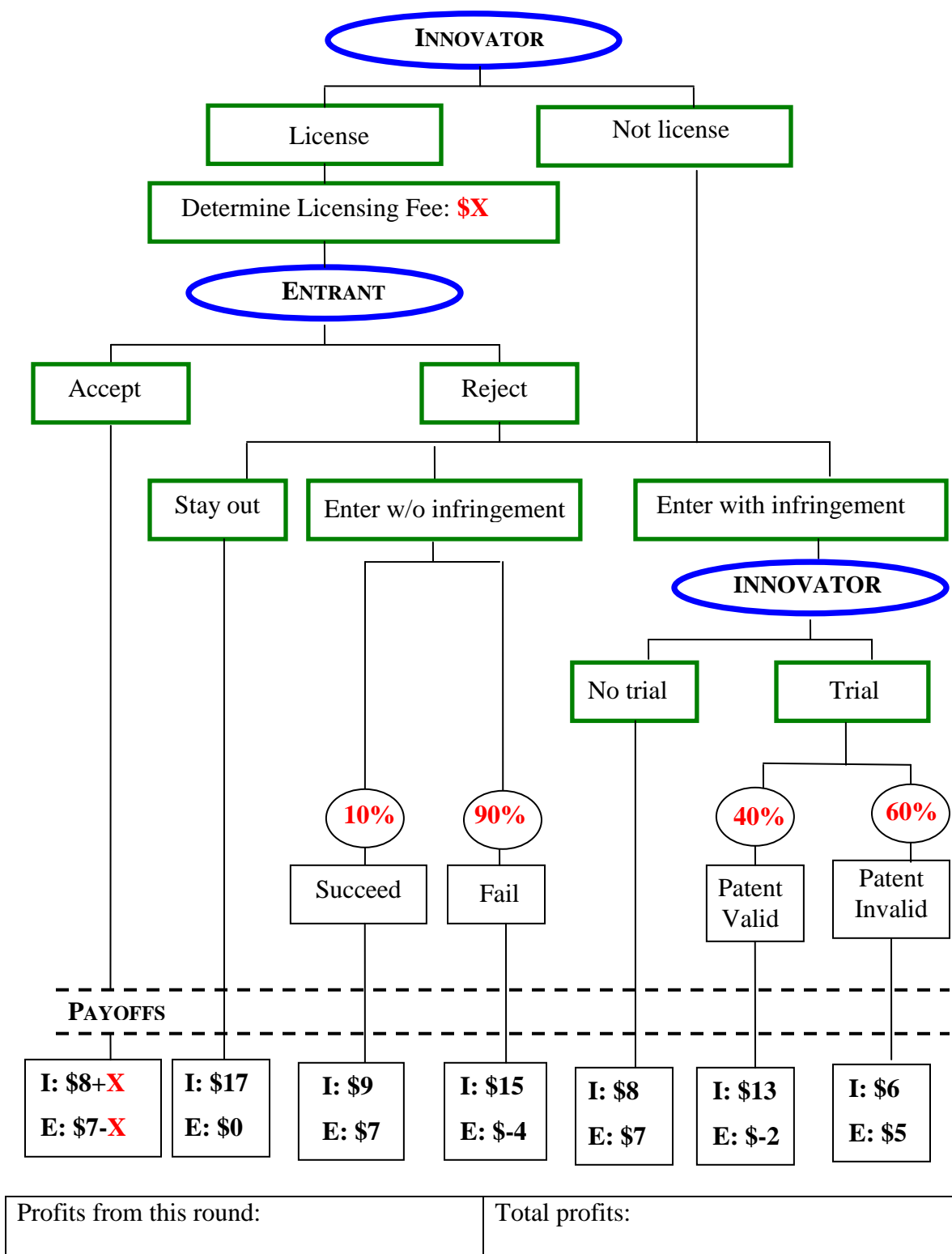
Scenario E

The market conditions under scenario E are similar to those under scenario C. The only difference between the two scenarios is that under scenario E each player can view only their own payoffs.

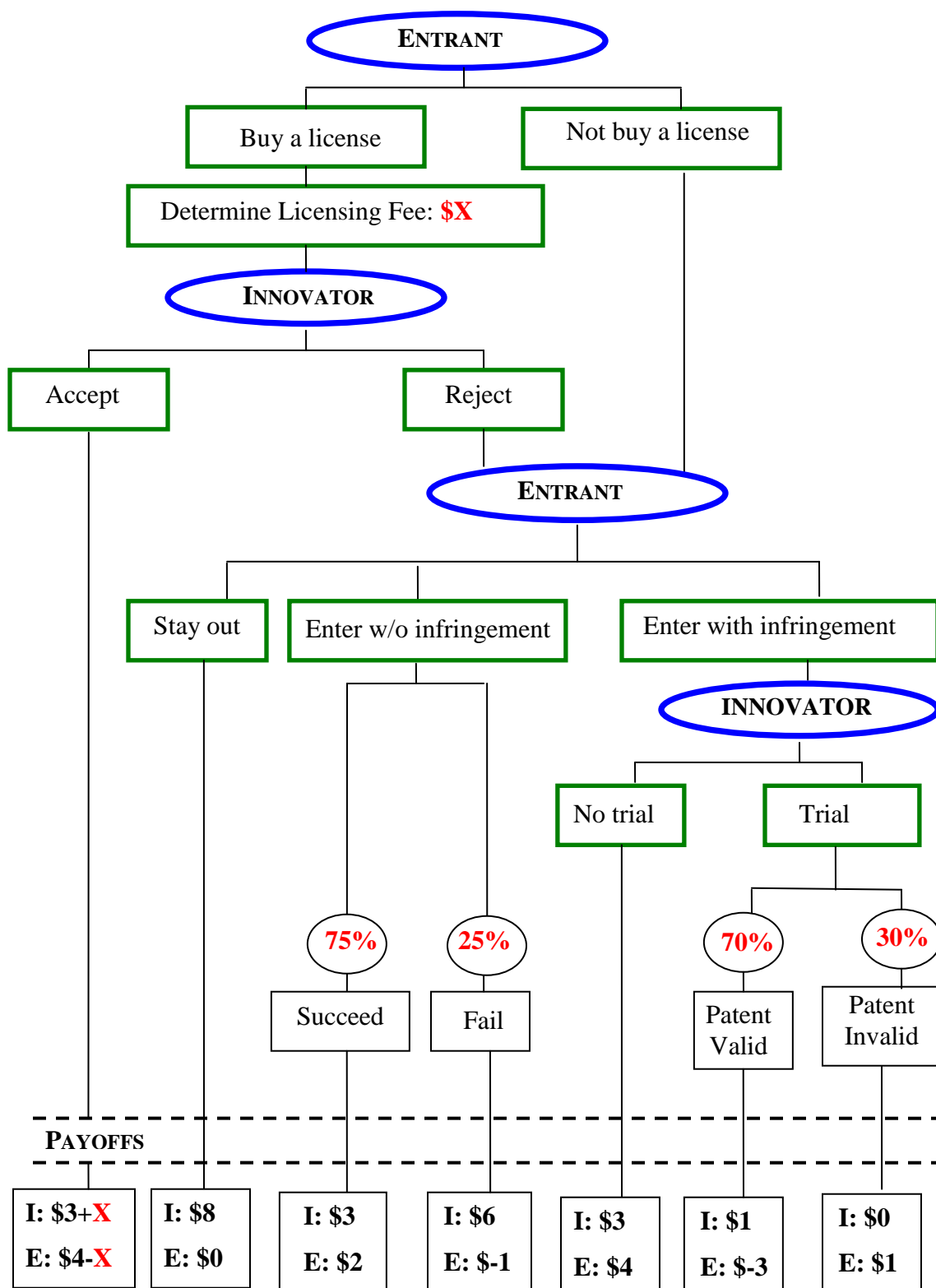
Scenario F

The market conditions under scenario F are similar to those under scenario D. The only difference between the two scenarios is that under scenario F each player can view only their own payoffs.

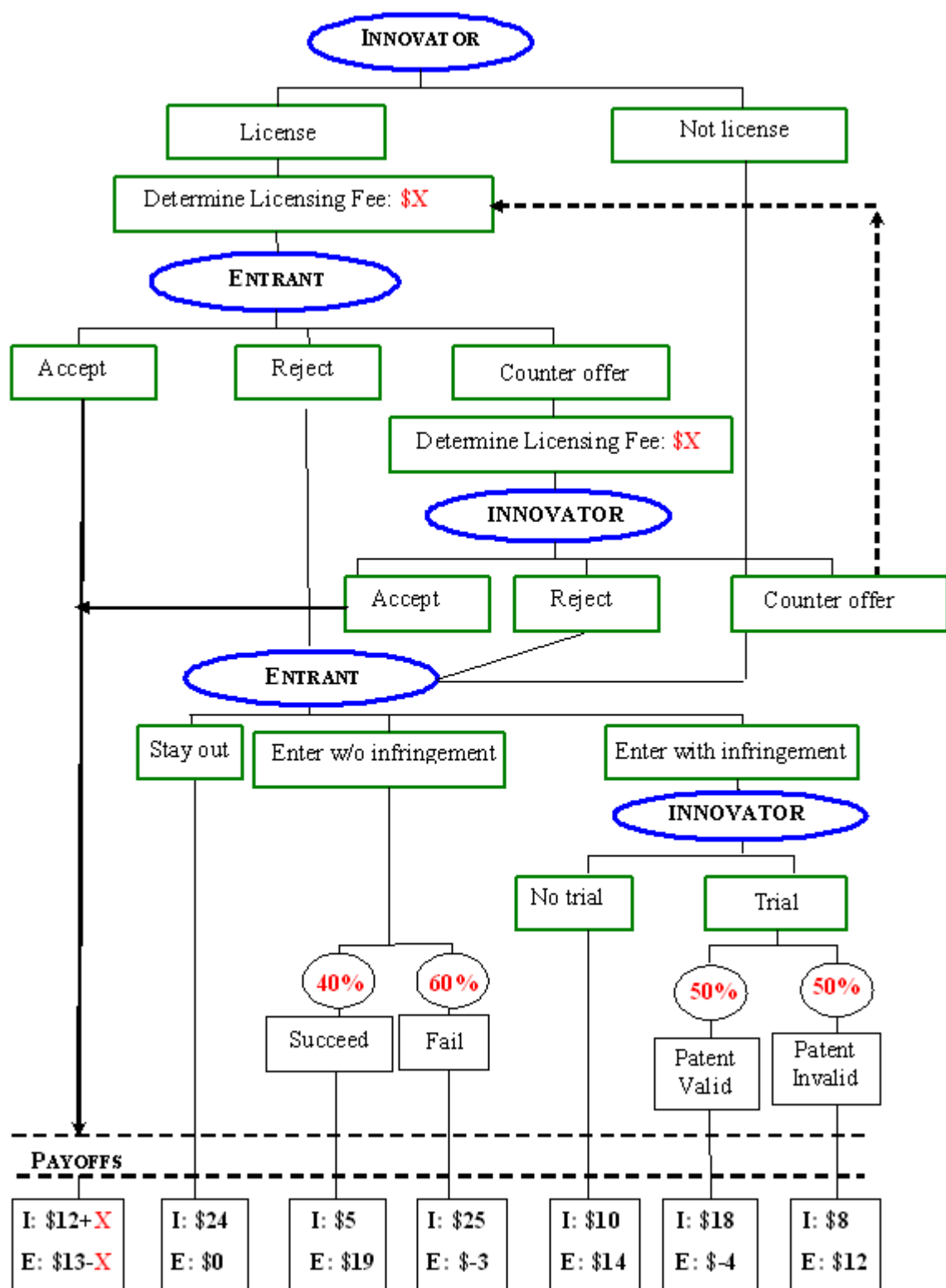
Scenario A



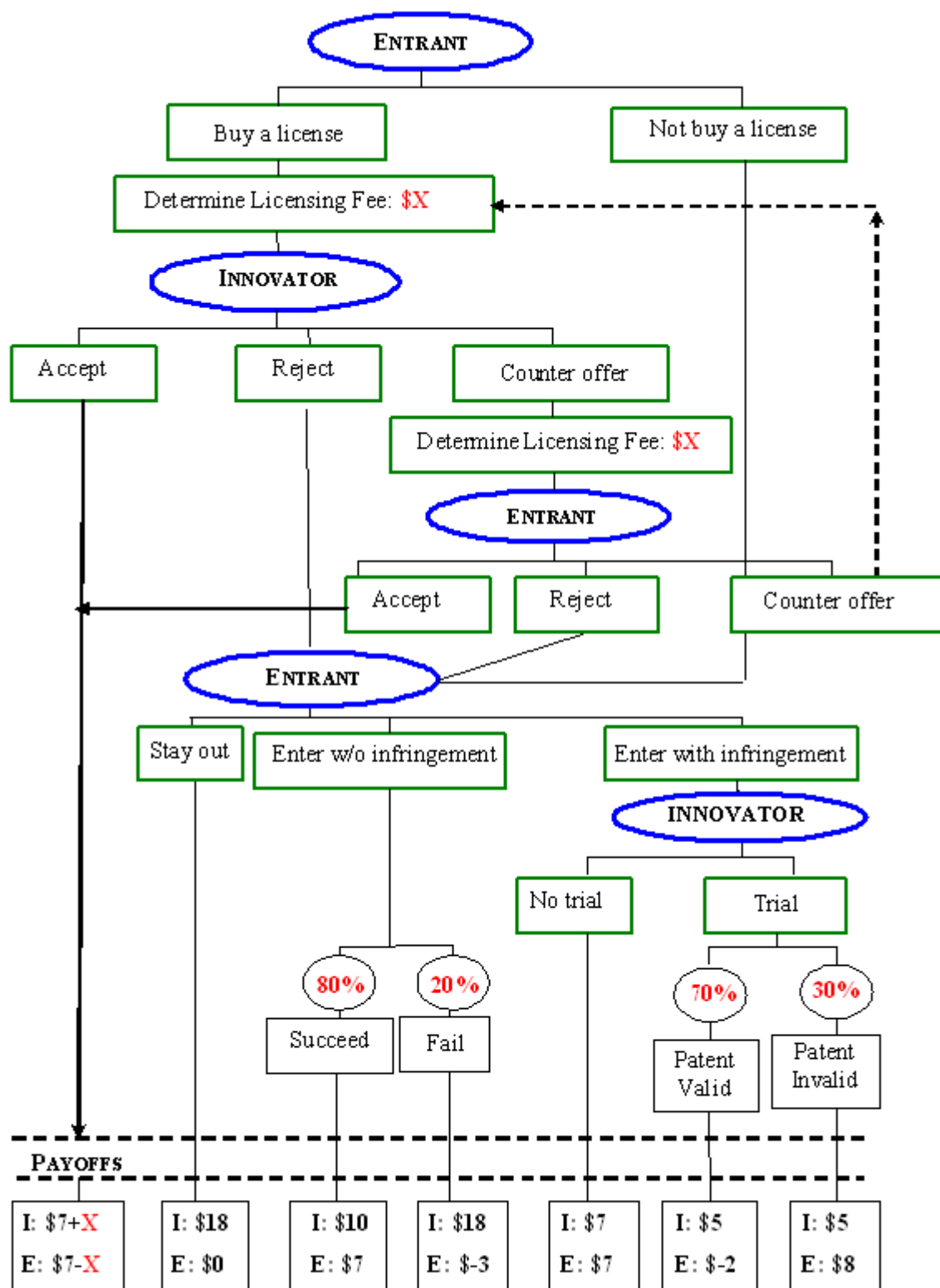
Scenario B



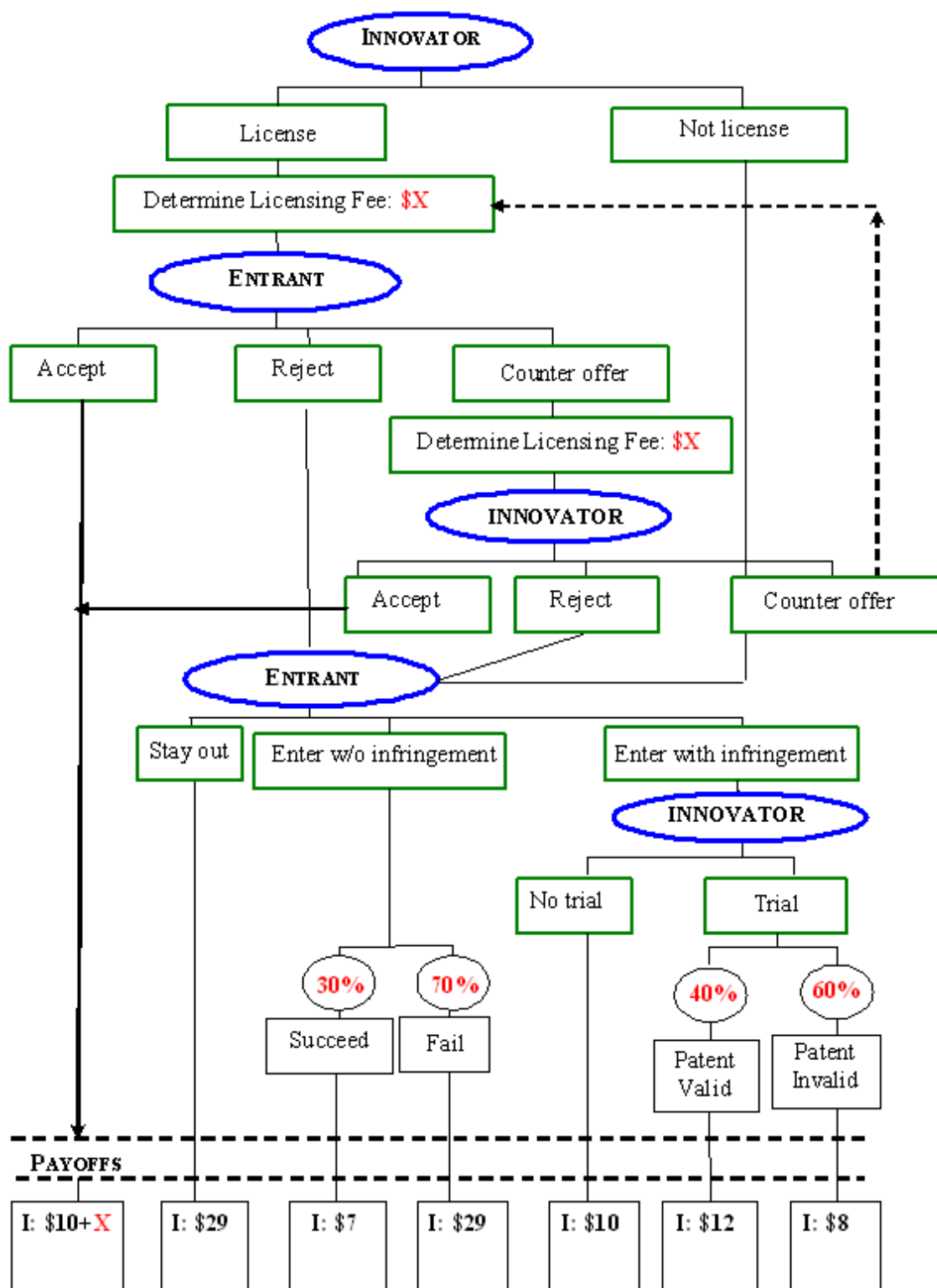
Scenario C



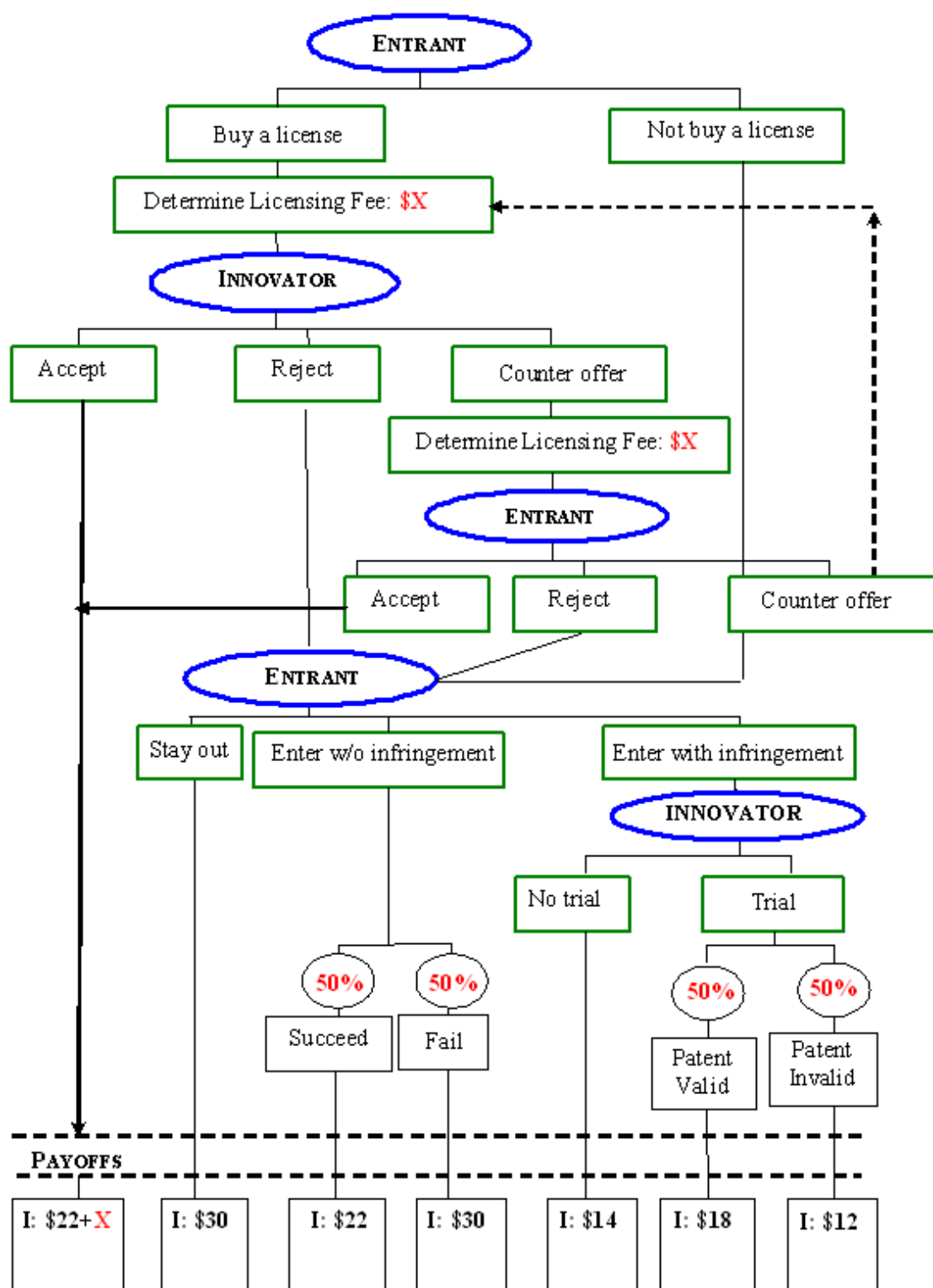
Scenario D



Scenario E



Scenario F



APPENDIX C: RESULTS OF EXPERIMENT 1

Table 2: Frequency tables for Group A

Round 1	Round 2			
		Weak	Strong	Total
	Weak	18	0	18
	Strong	1	1	2
Total		19	1	20

a – Control version

Round 1	Round 2			
		Weak	Strong	Total
	Weak	38	1	39
	Strong	1	0	1
Total		39	1	40

b – Randomized version

Round 1	Round 2			
		Weak	Strong	Total
	Weak	17	1	18
	Strong	0	0	0
Total		17	1	18

c – Randomized version (scenario 1 first)

Round 1	Round 2			
		Weak	Strong	Total
	Weak	21	0	21
	Strong	1	0	1
Total		22	0	22

d – Randomized version (scenario 2 first)

Table 3: Frequency tables for Group B

Round 3: weak Round 4	Round 5			
		Weak	Strong	Total
	Weak	20	0	20
	Strong	0	0	0
Total		20	0	20

a – Control version

Round 3: weak Round 4	Round 5			
		Weak	Strong	Total
	Weak	40	0	40
	Strong	0	0	0
Total		40	0	40

b – Randomized version

Round 3: weak Round 4	Round 5			
		Weak	Strong	Total
	Weak	18	0	18
	Strong	0	0	0
Total		18	0	18

c – Randomized version (scenario 1 first)

Round 3: weak Round 4	Round 5			
		Weak	Strong	Total
	Weak	22	0	22
	Strong	0	0	0
Total		22	0	22

d – Randomized version (scenario 2 first)

Table 4: Frequency tables for Group C

Round 6	Weak	Strong	Total
	4	16	20

a – Control version

Round 6	Weak	Strong	Total
	17	23	40

b – Randomized version

Round 6	Weak	Strong	Total
	7	11	18

c – Randomized version (scenario 1 first)

Round 6	Weak	Strong	Total
	10	12	22

d – Randomized version (scenario 2 first)

Table 5: Results summary for Groups D to G

	AAA	AAB	ABB	ABA	BBB	BBA	BAA	BAB
Rounds 7 to 9	1	5	4	0	10	0	0	0
Rounds 10 to 12	8	0	0	1	10	0	1	0
Rounds 13 to 15	2	5	1	0	12	0	0	0
Rounds 16 to 18	10	1	0	0	8	0	1	0

a- Control version

	AAA	AAB	ABB	ABA	BBB	BBA	BAA	BAB
Rounds 7 to 9	9	10	5	1	15	0	0	0
Rounds 10 to 12	6	0	1	1	17	6	9	0
Rounds 13 to 15	2	8	7	1	19	0	0	3
Rounds 16 to 18	18	1	1	3	11	5	1	0

b- Randomized version

	AAA	AAB	ABB	ABA	BBB	BBA	BAA	BAB
Rounds 7 to 9	5	5	3	0	5	0	0	0
Rounds 10 to 12	2	0	1	0	7	4	4	0
Rounds 13 to 15	1	4	4	0	7	0	0	2
Rounds 16 to 18	8	1	1	2	4	1	1	0

c- Randomized version (scenario 1 first)

	AAA	AAB	ABB	ABA	BBB	BBA	BAA	BAB
Rounds 7 to 9	4	5	2	1	10	0	0	0
Rounds 10 to 12	4	0	0	1	10	2	5	0
Rounds 13 to 15	1	4	3	1	12	0	0	1
Rounds 16 to 18	10	0	0	1	7	4	0	0

d- Randomized version (scenario 2 first)

* A: licensing to the weak rival and B: licensing to the strong rival

Table 6: Frequency tables for Groups D to G (aggregated data)

Group D				
license	PSN			
1.Frequency				
2.%				
3.Row %				
4.Col %	592	750	928	
A*	11	25	35	71
	6.11	13.89	19.44	39.44
	15.49	35.21	49.30	
	18.33	41.67	58.33	
B**	49	35	25	109
	27.22	19.44	13.89	60.56
	44.95	32.11	22.94	
	81.67	58.33	41.67	
Total	60	60	60	180
	33.33	33.33	33.33	100.00

Group E				
license	MSWN			
1.Frequency				
2.%				
3.Row %				
4.Col %	60	75	90	
A*	17	24	32	73
	9.44	13.33	17.78	40.56
	23.29	32.88	43.84	
	28.33	40.00	53.33	
B**	43	36	28	107
	23.89	20.00	15.56	59.44
	40.19	33.64	26.17	
	71.67	60.00	46.67	
Total	60	60	60	180
	33.33	33.33	33.33	100.00

Group F				
license	PS			
1.Frequency				
2.%				
3.Row %				
4.Col %	G1	G2	G3	
A*	26	20	5	51
	14.44	11.11	2.78	28.33
	50.98	39.22	9.80	
	43.33	33.33	8.33	
B**	34	40	55	129
	18.89	22.22	30.56	71.67
	26.36	31.01	42.64	
	56.67	66.67	91.67	
Total	60	60	60	180
	33.33	33.33	33.33	100.00

Group G				
license	MSW			
1.Frequency				
2.%				
3.Row %				
4.Col %	G1	G2	G3	
A*	34	32	38	104
	18.89	17.78	21.11	57.78
	32.69	30.77	36.54	
	56.67	53.33	63.33	
B**	26	28	22	76
	14.44	15.56	12.22	42.22
	34.21	36.84	28.95	
	43.33	46.67	36.67	
Total	60	60	60	180
	33.33	33.33	33.33	100.00

* A represents the decision of licensing to the weak rival

** B represents the decision of licensing to the strong rival

Table 7: Results of Groups D to G

Group D

PSN Least Squares Means							
PSN	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
592	-1.4939	0.3365	59	-4.44	<.0001	0.1833	0.05038
750	-0.3365	0.2641	59	-1.27	0.2076	0.4167	0.06418
928	0.3365	0.2641	59	1.27	0.2076	0.5833	0.06418
Differences of PSN Least Squares Means							
PSN	_PSN	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
592	750	-1.1575	0.3144	59	-3.68	0.0005	0.314
592	928	-1.8304	0.3343	59	-5.47	<.0001	0.160
750	928	-0.6729	0.1996	59	-3.37	0.0013	0.510

Group F

PS Least Squares Means							
PS	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
G1*	0.2683	0.2627	59	1.02	0.3114	0.5667	0.06451
G2*	0.6931	0.2762	59	2.51	0.0148	0.6667	0.06137
G3*	2.3979	0.4710	59	5.09	<.0001	0.9167	0.03598
Differences of PS Least Squares Means							
PS	_PS	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
G1	G2	-0.4249	0.2429	59	-1.75	0.0855	0.654
G1	G3	-2.1296	0.4534	59	-4.70	<.0001	0.119
G2	G3	-1.7047	0.4696	59	-3.63	0.0006	0.182

* G1= 1.25D, G2=1.5D and G3=2D

Group E

MSWN Least Squares Means							
MSWN	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
60	-0.9280	0.2889	118	-3.21	0.0017	0.2833	0.05867
75	-0.4055	0.2657	118	-1.53	0.1297	0.4000	0.06378
90	0.1335	0.2610	118	0.51	0.6098	0.5333	0.06495
Differences of MSWN Least Squares Means							
MSWN	_MSWN	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
60	75	-0.5225	0.2318	118	-2.25	0.0260	0.593
60	90	-1.0615	0.2952	118	-3.60	0.0005	0.346
75	90	-0.5390	0.2192	118	-2.46	0.0154	0.583

Group G

Simple Effect Comparisons of order*MSW LS Means By MSW								
Simple Effect Level	order	_order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
G1	F	R	-0.1016	0.5611	116	-0.18	0.8566	0.903
G2	F	R	0.4055	0.5648	116	0.72	0.4742	1.500
G3	F	R	-0.5302	0.5717	116	-0.93	0.3557	0.588
Simple Effect Comparisons of order*MSW LS Means By order								
Simple Effect Level	MSW	_MSW	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
F	G1	G2	-0.2048	0.3262	116	-0.63	0.5313	0.815
F	G1	G3	1.55E-15	0.4280	116	0.00	1.0000	1.000
F	G2	G3	0.2048	0.3262	116	0.63	0.5313	1.227
R	G1	G2	0.3023	0.2290	116	1.32	0.1894	1.353
R	G1	G3	-0.4286	0.3134	116	-1.37	0.1741	0.651
R	G2	G3	-0.7309	0.2362	116	-3.09	0.0025	0.481

* G1= 1.5C, G2=1.75C and G3= 2C

Table 8: Frequency tables for Scenario 2

Info = G					
Switch	PENTWS				
1.Frequency					
2.%					
3.Row %					
4.Col %	20,20	40,40	60,60	80,80	Total
0	23 9.58 29.49 38.33	16 6.67 20.51 26.67	20 8.33 25.64 33.33	19 7.92 24.36 31.67	78 32.50
1	37 15.42 22.84 61.67	44 18.33 27.16 73.33	40 16.67 24.69 66.67	41 17.08 25.31 68.33	162 67.50
Total	60 25.00	60 25.00	60 25.00	60 25.00	240 100.00

Info = O								
Switch	PENTWS							
1.Frequency								
2.%								
3.Row %								
4.Col %	20,20	20,40	20,60	20,80	40,40	60,60	80,80	Total
0	23 5.48 29.87 38.33	11 2.62 14.29 18.33	5 1.19 6.49 8.33	7 1.67 9.09 11.67	12 2.86 15.58 20.00	13 3.10 16.88 21.67	6 1.43 7.79 10.00	77 18.33
1	37 8.81 10.79 61.67	49 11.67 14.29 81.67	55 13.10 16.03 91.67	53 12.62 15.45 88.33	48 11.43 13.99 80.00	47 11.19 13.70 78.33	54 12.86 15.74 90.00	343 81.67
Total	60 14.29	60 14.29	60 14.29	60 14.29	60 14.29	60 14.29	60 14.29	420 100.00

Table 9: Frequency tables for rounds 1 to 4

Table of Q11 by Q12			
Q11	Q12		
1.Frequency			
2.%			
3.Row %			
4.Col %	0	1	Total
0	17 28.33 53.13 73.91	15 25.00 46.88 40.54	32 53.33
1	6 10.00 21.43 26.09	22 36.67 78.57 59.46	28 46.67
Total	23 38.33	37 61.67	60 100.00

Table of Q31 by Q32			
Q31	Q32		
1.Frequency			
2.%			
3.Row %			
4.Col %	0	1	Total
0	11 18.33 34.38 55.00	21 35.00 65.63 52.50	32 53.33
1	9 15.00 32.14 45.00	19 31.67 67.86 47.50	28 46.67
Total	20 33.33	40 66.67	60 100.00

Table of Q21 by Q22			
Q21	Q22		
1.Frequency			
2.%			
3.Row %			
4.Col %	0	1	Total
0	12 20.00 37.50 75.00	20 33.33 62.50 45.45	32 53.33
1	4 6.67 14.29 25.00	24 40.00 85.71 54.55	28 46.67
Total	16 26.67	44 73.33	60 100.00

Table of Q41 by Q42			
Q41	Q42		
1.Frequency			
2.%			
3.Row %			
4.Col %	0	1	Total
0	9 15.00 30.00 47.37	21 35.00 70.00 51.22	30 50.00
1	10 16.67 33.33 52.63	20 33.33 66.67 48.78	30 50.00
Total	19 31.67	41 68.33	60 100.00

Table 10: Results of switching decision

v Least Squares Means							
v	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
0	0.4725	0.2154	25	2.19	0.0377	0.6160	0.05095
1	-1.1083	0.2520	25	-4.40	0.0002	0.2482	0.04703

Differences of v Least Squares Means							
v	_v	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
0	1	1.5808	0.3012	25	5.25	<.0001	4.859

Table 11: Results of switching decision by probability

v Least Squares Means when P=20							
v	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
0	-0.1252	0.3603	58	-0.35	0.7296	0.4688	0.08972
1	-1.2993	0.4684	58	-2.77	0.0074	0.2143	0.07887

v Least Squares Means when P=40%							
v	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
0	0.5108	0.3714	58	1.38	0.1743	0.6250	0.08704
1	-1.7918	0.5493	58	-3.26	0.0019	0.1429	0.06726

v Least Squares Means when P=60%							
v	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
0	0.6466	0.3786	58	1.71	0.0930	0.6563	0.08540
1	-0.7472	0.4116	58	-1.82	0.0746	0.3214	0.08977

v Least Squares Means when P=80%							
v	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
0	0.8473	0.4052	58	2.09	0.0409	0.7000	0.08510
1	-0.6931	0.3939	58	-1.76	0.0837	0.3333	0.08754

Table 12: Results of scenario 2

a. Info Least Squares Means							
Info	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
G	1.0406	0.2069	59	5.03	<.0001	0.7390	0.03991
O	1.5631	0.1616	59	9.67	<.0001	0.8268	0.02314

b. Differences of Info Least Squares Means							
Info	_Info	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
G	O	-0.5226	0.2371	59	-2.20	0.0314	0.593

c. PENTWS Least Squares Means							
PENTWS	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
20,20	0.5151	0.1898	354	2.71	0.0070	0.6260	0.04444
20,40	1.1381	0.3319	354	3.43	0.0007	0.7573	0.06100
20,60	2.1074	0.4751	354	4.44	<.0001	0.8916	0.04591
20,80	1.7576	0.4190	354	4.19	<.0001	0.8529	0.05257
40,40	1.2146	0.2188	354	5.55	<.0001	0.7711	0.03861
60,60	0.9914	0.2076	354	4.77	<.0001	0.7294	0.04099
80,80	1.3889	0.2304	354	6.03	<.0001	0.8004	0.03681

d. Differences of PENTWS Least Squares Means							
PENTWS	_PENTWS	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
20,20	20,40	-0.6230	0.3789	354	-1.64	0.1010	0.536
20,20	20,60	-1.5923	0.5104	354	-3.12	0.0020	0.203
20,20	20,80	-1.2424	0.4592	354	-2.71	0.0072	0.289
20,20	40,40	-0.6994	0.2557	354	-2.74	0.0065	0.497
20,20	60,60	-0.4762	0.2710	354	-1.76	0.0797	0.621
20,20	80,80	-0.8738	0.2798	354	-3.12	0.0019	0.417
20,40	20,60	-0.9694	0.5026	354	-1.93	0.0546	0.379
20,40	20,80	-0.6195	0.5031	354	-1.23	0.2190	0.538
20,40	40,40	-0.07649	0.3986	354	-0.19	0.8479	0.926
20,40	60,60	0.1467	0.3900	354	0.38	0.7069	1.158
20,40	80,80	-0.2508	0.3856	354	-0.65	0.5158	0.778
20,60	20,80	0.3499	0.5422	354	0.65	0.5192	1.419
20,60	40,40	0.8929	0.5254	354	1.70	0.0901	2.442
20,60	60,60	1.1161	0.5209	354	2.14	0.0328	3.053
20,60	80,80	0.7186	0.5294	354	1.36	0.1755	2.051
20,80	40,40	0.5430	0.4759	354	1.14	0.2547	1.721
20,80	60,60	0.7662	0.4717	354	1.62	0.1052	2.152
20,80	80,80	0.3687	0.4858	354	0.76	0.4484	1.446
40,40	60,60	0.2232	0.2648	354	0.84	0.3998	1.250
40,40	80,80	-0.1743	0.3044	354	-0.57	0.5672	0.840
60,60	80,80	-0.3975	0.2717	354	-1.46	0.1443	0.672

APPENDIX D: RESULTS OF EXPERIMENT 2

Table 13: Frequency table of License by Result using aggregate data

License	Result							
1.Frequency								
2.%								
3.% Row								
4.% Col	Accept	Fail	Invalid	NoTrial	Out	Succeed	Valid	Total
No	0	104	209	71	19	247	146	796
	0.00	3.01	6.05	2.06	0.55	7.15	4.23	23.05
	0.00	13.07	26.26	8.92	2.39	31.03	18.34	
	0.00	37.41	35.19	39.89	79.17	39.71	41.95	
Yes	1410	174	385	107	5	375	202	2658
	40.82	5.04	11.15	3.10	0.14	10.86	5.85	76.95
	53.05	6.55	14.48	4.03	0.19	14.11	7.60	
	100.00	62.59	64.81	60.11	20.83	60.29	58.05	
Total	1410	278	594	178	24	622	348	3454
	40.82	8.05	17.20	5.15	0.69	18.01	10.08	100.00

Table 14: Frequency table of License by Result by scenario

Table of License by Result – Scenario A						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	Out	invest	notrial	trial	Total
No	0	3	57	7	72	139
	0.00	0.52	9.90	1.22	12.50	24.13
	0.00	2.16	41.01	5.04	51.80	
	0.00	60.00	38.26	21.21	36.18	
Yes	190	2	92	26	127	437
	32.99	0.35	15.97	4.51	22.05	75.87
	43.48	0.46	21.05	5.95	29.06	
	100.00	40.00	61.74	78.79	63.82	
Total	190	5	149	33	199	576
	32.99	0.87	25.87	5.73	34.55	100.00

Table of License by Result – Scenario B						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	invest	notrial	trial	Total	
No	0	52	19	59	130	
	0.00	9.04	3.30	10.26	22.61	
	0.00	40.00	14.62	45.38		
	0.00	33.77	57.58	39.33		
Yes	238	102	14	91	445	
	41.39	17.74	2.43	15.83	77.39	
	53.48	22.92	3.15	20.45		
	100.00	66.23	42.42	60.67		
Total	238	154	33	150	575	
	41.39	26.78	5.74	26.09	100.00	

Table of License by Result – Scenario C						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	Out	invest	notrial	trial	Total
No	0	3	75	11	81	170
	0.00	0.52	13.04	1.91	14.09	29.57
	0.00	1.76	44.12	6.47	47.65	
	0.00	75.00	45.45	40.74	51.27	
Yes	221	1	90	16	77	405
	38.43	0.17	15.65	2.78	13.39	70.43
	54.57	0.25	22.22	3.95	19.01	
	100.00	25.00	54.55	59.26	48.73	
Total	221	4	165	27	158	575
	38.43	0.70	28.70	4.70	27.48	100.00

Table of License by Result – Scenario D						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	Out	invest	notrial	trial	Total
No	0	5	66	17	49	137
	0.00	0.87	11.46	2.95	8.51	23.78
	0.00	3.65	48.18	12.41	35.77	
	0.00	100.00	43.42	68.00	39.20	
Yes	269	0	86	8	76	439
	46.70	0.00	14.93	1.39	13.19	76.22
	61.28	0.00	19.59	1.82	17.31	
	100.00	0.00	56.58	32.00	60.80	
Total	269	5	152	25	125	576
	46.70	0.87	26.39	4.34	21.70	100.00

Table 14: Frequency table of License by Result by scenario (contd.)

Table of License by Result - Scenario E						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	Out	invest	notrial	trial	Total
No	0	5	48	9	62	124
	0.00	0.87	8.33	1.56	10.76	21.53
	0.00	4.03	38.71	7.26	50.00	
	0.00	83.33	35.29	25.00	33.70	
Yes	214	1	88	27	122	452
	37.15	0.17	15.28	4.69	21.18	78.47
	47.35	0.22	19.47	5.97	26.99	
	100.00	16.67	64.71	75.00	66.30	
Total	214	6	136	36	184	576
	37.15	1.04	23.61	6.25	31.94	100.00

Table of License by Result – Scenario F						
License	Result					
1.Frequency						
2.%						
3.% Row						
4.% Col	Accept	Out	invest	notrial	trial	Total
No	0	3	53	8	32	96
	0.00	0.52	9.20	1.39	5.56	16.67
	0.00	3.13	55.21	8.33	33.33	
	0.00	75.00	36.81	33.33	25.40	
Yes	278	1	91	16	94	480
	48.26	0.17	15.80	2.78	16.32	83.33
	57.92	0.21	18.96	3.33	19.58	
	100.00	25.00	63.19	66.67	74.60	
Total	278	4	144	24	126	576
	48.26	0.69	25.00	4.17	21.88	100.00

Table 15: Frequency table Breadth by License controlling for the type of the potential entrant

Controlling for type = same			
Breadth	License		
1.Freq			
2.%			
3.% Row			
4.% Col	No	Yes	Total
broad	74	214	288
	12.85	37.15	50.00
	25.69	74.31	
	46.54	51.32	
narrow	85	203	288
	14.76	35.24	50.00
	29.51	70.49	
	53.46	48.68	
Total	159	417	576
	27.60	72.40	100

Controlling for type = strong			
Breadth	License		
1.Freq			
2.%			
3.%Row			
4.% Col	No	Yes	Total
broad	63	225	288
	10.96	39.13	50.09
	21.88	78.13	
	46.32	51.25	
narrow	73	214	287
	12.70	37.22	49.91
	25.44	74.56	
	53.68	48.75	
Total	136	439	575
	23.65	76.35	100

Controlling for type = weak			
Breadth	License		
1.Freq			
2.%			
3.%Row			
4.% Col	No	Yes	Total
broad	61	227	288
	10.59	39.41	50.00
	21.18	78.82	
	44.20	51.83	
narrow	77	211	288
	13.37	36.63	50.00
	26.74	73.26	
	55.80	48.17	
Total	138	438	576
	23.96	76.04	100

Table 16: Frequency table Breadth by License

Scenario A				Scenario C				Scenario E			
Breadth	License			Breadth	License			Breadth	License		
1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total	1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total	1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total
broad	57	231	288	broad	77	211	288	broad	64	224	288
	9.90	40.10	50.00		13.39	36.70	50.09		11.11	38.89	50.00
	19.79	80.21			26.74	73.26			22.22	77.78	
	41.01	52.86			45.29	52.10			51.61	49.56	
narrow	82	206	288	narrow	93	194	287	narrow	60	228	288
	14.24	35.76	50.00		16.17	33.74	49.91		10.42	39.58	50.00
	28.47	71.53			32.40	67.60			20.83	79.17	
	58.99	47.14			54.71	47.90			48.39	50.44	
Total	139	437	576	Total	170	405	575	Total	124	452	576
	24.13	75.87	100.00		29.57	70.43	100.00		21.53	78.47	100.00

Table 17: Frequency table Type by License

Scenario A				Scenario C				Scenario E			
Type	License			Type	License			Type	License		
1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total	1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total	1.Freq 2.% 3.%Row 4.%Col	No	Yes	Total
same	49	143	192	same	64	128	192	same	46	146	192
	8.51	24.83	33.33		11.13	22.26	33.39		7.99	25.35	33.33
	25.52	74.48			33.33	66.67			23.96	76.04	
	35.25	32.72			37.65	31.60			37.10	32.30	
strong	44	148	192	strong	45	146	191	strong	47	145	192
	7.64	25.69	33.33		7.83	25.39	33.22		8.16	25.17	33.33
	22.92	77.08			23.56	76.44			24.48	75.52	
	31.65	33.87			26.47	36.05			37.90	32.08	
weak	46	146	192	weak	61	131	192	weak	31	161	192
	7.99	25.35	33.33		10.61	22.78	33.39		5.38	27.95	33.33
	23.96	76.04			31.77	68.23			16.15	83.85	
	33.09	33.41			35.88	32.35			25.00	35.62	
Total	139	437	576	Total	170	405	575	Total	124	452	576
	24.13	75.87	100.00		29.57	70.43	100.00		21.53	78.47	100.00

Table 18: Type III Tests of Fixed Effects

Scenario A				
Effect	Num DF	Den DF	F Value	Pr > F
Role	1	47	4.30	0.0435
Order	1	477	0.02	0.8783
Breadth	1	477	6.97	0.0086
Type	2	477	0.22	0.8053

Scenario C				
Effect	Num DF	Den DF	F Value	Pr > F
Role	1	47	0.10	0.7556
Order	1	476	0.22	0.6424
Breadth	1	476	2.57	0.1094
Type	2	476	2.95	0.0532

Scenario E				
Effect	Num DF	Den DF	F Value	Pr > F
Role	1	47	2.77	0.1027
Order	1	477	0.65	0.4197
Breadth	1	477	0.21	0.6507
Type	2	477	3.01	0.0501

Table 19: Results of licensing decision for Scenario A

Role Least Squares Means							
Role	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
first	1.6341	0.2411	47	6.78	<.0001	0.8367	0.03294
second	1.0903	0.2273	47	4.80	<.0001	0.7484	0.04280

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	1.6458	0.2290	479	7.19	<.0001	0.8383	0.03104
narrow	1.0786	0.2150	479	5.02	<.0001	0.7462	0.04071

Differences of Role Least Squares Means							
Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
first	second	0.5438	0.2620	47	2.08	0.0435	1.722

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	0.5671	0.2153	479	2.63	0.0087	1.763

Table 20: Type III Tests of Fixed effects for licensing decision using aggregate data

Effect	Num DF	Den DF	F Value	Pr > F
Scenario	2	1608	5.84	0.0030
Order	1	1608	0.19	0.6662
Scenario*Order	2	1608	0.61	0.5450
Role	1	46	1.29	0.2615
Scenario*Role	2	1608	4.00	0.0185
Order*Role	1	1608	0.04	0.8457
Breadth	1	1608	4.74	0.0296
Scenario*Breadth	2	1608	2.52	0.0807
Order*Breadth	1	1608	0.04	0.8408
Role*Breadth	1	1608	0.12	0.7282
Type	2	1608	2.64	0.0714
Scenario*Type	4	1608	2.43	0.0456
Order*Type	2	1608	1.78	0.1689
Role*Type	2	1608	0.21	0.8116
Breadth*Type	2	1608	0.09	0.9100

Table 21: Main effect of Breadth

a. Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
Broad	1.6100	0.2027	1620	7.94	<.0001	0.8334	0.02815
Narrow	1.3109	0.1999	1620	6.56	<.0001	0.7877	0.03344

b. Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Broad	Narrow	0.2991	0.1274	1620	2.35	0.0190	1.349

Table 22: Simple effect comparisons of Scenario*Role Least Squares Means

a. Controlling for Role								
Simple Effect Level	Scenario	Scenario	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role first	A	C	0.7453	0.2248	1620	3.32	0.0009	2.107
Role first	A	E	-0.1941	0.2424	1620	-0.80	0.4234	0.824
Role first	C	E	-0.9395	0.2314	1620	-4.06	<.0001	0.391
Role second	A	C	-0.00833	0.2098	1620	-0.04	0.9683	0.992
Role second	A	E	-0.2178	0.2134	1620	-1.02	0.3077	0.804
Role second	C	E	-0.2095	0.2142	1620	-0.98	0.3282	0.811

b. Controlling for Scenario								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Scenario A	first	second	0.6300	0.3292	1620	1.91	0.0558	1.878
Scenario C	first	second	-0.1236	0.3175	1620	-0.39	0.6971	0.884
Scenario E	first	second	0.6064	0.3362	1620	1.80	0.0714	1.834

Table 23: Simple effect comparisons of Scenario*type Least Squares Means

a. Controlling for Type								
Simple Effect Level	Scenario	Scenario	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Type same	A	C	0.5135	0.2586	1620	1.99	0.0473	1.671
Type same	A	E	-0.1073	0.2699	1620	-0.40	0.6911	0.898
Type same	C	E	-0.6207	0.2613	1620	-2.38	0.0176	0.538
Type strong	A	C	0.06358	0.2746	1620	0.23	0.8169	1.066
Type strong	A	E	0.1129	0.2734	1620	0.41	0.6796	1.120
Type strong	C	E	0.04935	0.2718	1620	0.18	0.8560	1.051
Type weak	A	C	0.5285	0.2625	1620	2.01	0.0442	1.696
Type weak	A	E	-0.6235	0.2927	1620	-2.13	0.0333	0.536
Type weak	C	E	-1.1520	0.2838	1620	-4.06	<.0001	0.316

b. Controlling for Scenario								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Scenario A	same	strong	-0.1835	0.2712	1620	-0.68	0.4986	0.832
Scenario A	same	weak	-0.1087	0.2693	1620	-0.40	0.6865	0.897
Scenario A	strong	weak	0.07482	0.2736	1620	0.27	0.7845	1.078
Scenario C	same	strong	-0.6334	0.2614	1620	-2.42	0.0155	0.531
Scenario C	same	weak	-0.09371	0.2500	1620	-0.37	0.7078	0.911
Scenario C	strong	weak	0.5397	0.2626	1620	2.06	0.0400	1.716
Scenario E	same	strong	0.03666	0.2708	1620	0.14	0.8923	1.037
Scenario E	same	weak	-0.6250	0.2918	1620	-2.14	0.0323	0.535
Scenario E	strong	weak	-0.6616	0.2910	1620	-2.27	0.0231	0.516

Table 24: Least Squares Means of Scenario*Role and Scenario*Type

a. Scenario*Role Least Squares Means								
Scenario	Role	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
A	first	1.8297	0.2757	1620	6.64	<.0001	0.8617	0.03285
A	second	1.1996	0.2609	1620	4.60	<.0001	0.7685	0.04642
C	first	1.0843	0.2613	1620	4.15	<.0001	0.7473	0.04934
C	second	1.2080	0.2614	1620	4.62	<.0001	0.7699	0.04630
E	first	2.0238	0.2812	1620	7.20	<.0001	0.8833	0.02899
E	second	1.4174	0.2649	1620	5.35	<.0001	0.8049	0.04159

b. Scenario*Type Least Squares Means								
Scenario	Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
A	same	1.4172	0.2610	1620	5.43	<.0001	0.8049	0.04099
A	strong	1.6008	0.2659	1620	6.02	<.0001	0.8321	0.03714
A	weak	1.5260	0.2638	1620	5.78	<.0001	0.8214	0.03870
C	same	0.9038	0.2504	1620	3.61	0.0003	0.7117	0.05138
C	strong	1.5372	0.2640	1620	5.82	<.0001	0.8231	0.03844
C	weak	0.9975	0.2519	1620	3.96	<.0001	0.7306	0.04959
E	same	1.5245	0.2638	1620	5.78	<.0001	0.8212	0.03873
E	strong	1.4879	0.2628	1620	5.66	<.0001	0.8158	0.03950
E	weak	2.1495	0.2855	1620	7.53	<.0001	0.8956	0.02669

Table 25: Frequency table of Accept by Scenario

accept	Scenario						
1.Freq 2.% 3.%Row 4.%Col							
	A	B	C	D	E	F	Total
0	247	207	184	170	238	202	1248
	9.29	7.79	6.92	6.40	8.95	7.60	46.95
	19.79	16.59	14.74	13.62	19.07	16.19	
	56.52	46.52	45.43	38.72	52.65	42.08	
1	190	238	221	269	214	278	1410
	7.15	8.95	8.31	10.12	8.05	10.46	53.05
	13.48	16.88	15.67	19.08	15.18	19.72	
	43.48	53.48	54.57	61.28	47.35	57.92	
Total	437	445	405	439	452	480	2658
	16.44	16.74	15.24	16.52	17.01	18.06	100.00
Frequency Missing = 2							

Table 26: Frequency table Breadth*Accept under different market conditions

Controlling for scenario=A			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	147	84	231
	33.64	19.22	52.86
	63.64	36.36	
	59.51	44.21	
narrow	100	106	206
	22.88	24.26	47.14
	48.54	51.46	
	40.49	55.79	
Total	247	190	437
	56.52	43.48	100.00

Controlling for scenario=B			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	89	129	218
	20.00	28.99	48.99
	40.83	59.17	
	43.00	54.20	
narrow	118	109	227
	26.52	24.49	51.01
	51.98	48.02	
	57.00	45.80	
Total	207	238	445
	46.52	53.48	100.00

Controlling for scenario=C			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	92	119	211
	22.72	29.38	52.10
	43.60	56.40	
	50.00	53.85	
narrow	92	102	194
	22.72	25.19	47.90
	47.42	52.58	
	50.00	46.15	
Total	184	221	405
	45.43	54.57	100.00

Controlling for scenario=D			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	79	147	226
	18.00	33.49	51.48
	34.96	65.04	
	46.47	54.65	
narrow	91	122	213
	20.73	27.79	48.52
	42.72	57.28	
	53.53	45.35	
Total	170	269	439
	38.72	61.28	100.00

Controlling for scenario=E			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	126	98	224
	27.88	21.68	49.56
	56.25	43.75	
	52.94	45.79	
narrow	112	116	228
	24.78	25.66	50.44
	49.12	50.88	
	47.06	54.21	
Total	238	214	452
	52.65	47.35	100.00

Controlling for scenario=F			
Breadth	accept		
1.Freq 2.% 3.%Row 4.%Col			
	0	1	Total
broad	99	148	247
	20.63	30.83	51.46
	40.08	59.92	
	49.01	53.24	
narrow	103	130	233
	21.46	27.08	48.54
	44.21	55.79	
	50.99	46.76	
Total	202	278	480
	42.08	57.92	100.00

Table 27: Frequency table Type*Accept under different market conditions

Controlling for scenario=A			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	74	69	143
	16.93	15.79	32.72
	51.75	48.25	
	29.96	36.32	
strong	84	64	148
	19.22	14.65	33.87
	56.76	43.24	
	34.01	33.68	
weak	89	57	146
	20.37	13.04	33.41
	60.96	39.04	
	36.03	30.00	
Total	247	190	437
	56.52	43.48	100.00

Controlling for scenario=B			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	66	83	149
	14.83	18.65	33.48
	44.30	55.70	
	31.88	34.87	
strong	77	69	146
	17.30	15.51	32.81
	52.74	47.26	
	37.20	28.99	
weak	64	86	150
	14.38	19.33	33.71
	42.67	57.33	
	30.92	36.13	
Total	207	238	445
	46.52	53.48	100.00

Controlling for scenario=C			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	66	62	128
	16.30	15.31	31.60
	51.56	48.44	
	35.87	28.05	
strong	61	85	146
	15.06	20.99	36.05
	41.78	58.22	
	33.15	38.46	
weak	57	74	131
	14.07	18.27	32.35
	43.51	56.49	
	30.98	33.48	
Total	184	221	405
	45.43	54.57	100.00

Controlling for scenario=D			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	62	86	148
	14.12	19.59	33.71
	41.89	58.11	
	36.47	31.97	
Strong	53	92	145
	12.07	20.96	33.03
	36.55	63.45	
	31.18	34.20	
Weak	55	91	146
	12.53	20.73	33.26
	37.67	62.33	
	32.35	33.83	
Total	170	269	439
	38.72	61.28	100.00

Controlling for scenario=E			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	81	65	146
	17.92	14.38	32.30
	55.48	44.52	
	34.03	30.37	
strong	63	82	145
	13.94	18.14	32.08
	43.45	56.55	
	26.47	38.32	
weak	94	67	161
	20.80	14.82	35.62
	58.39	41.61	
	39.50	31.31	
Total	238	214	452
	52.65	47.35	100.00

Controlling for scenario=F			
Type	accept		
1.Freq 2.% 3.%Row 4.%Col	0	1	
same	65	92	157
	13.54	19.17	32.71
	41.40	58.60	
	32.18	33.09	
strong	68	92	160
	14.17	19.17	33.33
	42.50	57.50	
	33.66	33.09	
weak	69	94	163
	14.38	19.58	33.96
	42.33	57.67	
	34.16	33.81	
Total	202	278	480
	42.08	57.92	100.00

Table 28: Results of licensing occurrence in scenario A

Role Least Squares Means							
Role	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
first	-0.6397	0.1968	45	-3.25	0.0022	0.3453	0.04449
second	0.1061	0.1999	45	0.53	0.5982	0.5265	0.04984

Differences of Role Least Squares Means							
Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
first	second	-0.7458	0.2740	45	-2.72	0.0092	0.474

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	-0.6189	0.1761	342	-3.51	0.0005	0.3500	0.04007
narrow	0.08525	0.1792	342	0.48	0.6345	0.5213	0.04472

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	-0.7041	0.2097	342	-3.36	0.0009	0.495

Table 29: Results of licensing occurrence in scenario B

Order Least Squares Means							
Order	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
f	-0.2594	0.2362	350	-1.10	0.2729	0.4355	0.05807
r	0.3406	0.1556	350	2.19	0.0293	0.5843	0.03779

Differences of Order Least Squares Means							
Order	Order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
f	r	-0.6000	0.2828	350	-2.12	0.0346	0.549

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	0.2810	0.1750	350	1.61	0.1091	0.5698	0.04289
narrow	-0.1999	0.1714	350	-1.17	0.2445	0.4502	0.04243

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	0.4809	0.2000	350	2.40	0.0167	1.618

Table 30: LSM estimates and Simple effects of Role*Breadth*Type in Scenario C

Role*Breadth*Type Least Squares Means									
Role	Breadth	Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
first	broad	same	-0.5906	0.4394	296	-1.34	0.1800	0.3565	0.1008
first	broad	strong	-0.00941	0.3929	296	-0.02	0.9809	0.4976	0.09822
first	broad	weak	0.5273	0.4219	296	1.25	0.2123	0.6289	0.09846
first	narrow	same	0.3878	0.4391	296	0.88	0.3778	0.5958	0.1058
first	narrow	strong	-0.1215	0.4002	296	-0.30	0.7617	0.4697	0.09969
first	narrow	weak	-0.2127	0.4467	296	-0.48	0.6343	0.4470	0.1104
second	broad	same	0.4339	0.4225	296	1.03	0.3052	0.6068	0.1008
second	broad	strong	1.2559	0.4517	296	2.78	0.0058	0.7783	0.07794
second	broad	weak	0.08589	0.4143	296	0.21	0.8359	0.5215	0.1034
second	narrow	same	-0.4809	0.4473	296	-1.08	0.2832	0.3820	0.1056
second	narrow	strong	-0.1947	0.4068	296	-0.48	0.6325	0.4515	0.1007
second	narrow	weak	0.4834	0.4451	296	1.09	0.2784	0.6185	0.1050

Simple Effect Comparisons of Role*Breadth*Type Least Squares Means By Role*Breadth										
Simple Effect Level			Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role*Breadth first broad			same	strong	-0.5812	0.5462	296	-1.06	0.2882	0.559
Role*Breadth first broad			same	weak	-1.1179	0.5689	296	-1.97	0.0503	0.327
Role*Breadth first broad			strong	weak	-0.5367	0.5340	296	-1.01	0.3157	0.585
Role*Breadth first narrow			same	strong	0.5093	0.5528	296	0.92	0.3576	1.664
Role*Breadth first narrow			same	weak	0.6005	0.5825	296	1.03	0.3034	1.823
Role*Breadth first narrow			strong	weak	0.09120	0.5549	296	0.16	0.8696	1.095
Role*Breadth second broad			same	strong	-0.8220	0.5785	296	-1.42	0.1564	0.440
Role*Breadth second broad			same	weak	0.3480	0.5492	296	0.63	0.5267	1.416
Role*Breadth second broad			strong	weak	1.1701	0.5733	296	2.04	0.0421	3.222
Role*Breadth second narrow			same	strong	-0.2862	0.5649	296	-0.51	0.6127	0.751
Role*Breadth second narrow			same	weak	-0.9643	0.5868	296	-1.64	0.1014	0.381
Role*Breadth second narrow			strong	weak	-0.6781	0.5627	296	-1.20	0.2292	0.508

Simple Effect Comparisons of Role*Breadth*Type Least Squares Means By Role*Type									
Simple Effect Level		Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role*Type first same		broad	narrow	-0.9784	0.5769	296	-1.70	0.0909	0.376
Role*Type first strong		broad	narrow	0.1121	0.5153	296	0.22	0.8280	1.119
Role*Type first weak		broad	narrow	0.7400	0.5768	296	1.28	0.2005	2.096
Role*Type second same		broad	narrow	0.9149	0.5721	296	1.60	0.1109	2.496
Role*Type sec strong		broad	narrow	1.4507	0.5676	296	2.56	0.0111	4.266
Role*Type second weak		broad	narrow	-0.3975	0.5674	296	-0.70	0.4842	0.672

Table 30: LSM estimates and Simple effects of Role*Breadth*Type in Scenario C
(contd)

Simple Effect Comparisons of Role*Breadth*Type Least Squares Means By Breadth*Type								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth*Type broad same	first	second	-1.0245	0.5700	296	-1.80	0.0733	0.359
Breadth*Type broad strong	first	second	-1.2654	0.5751	296	-2.20	0.0286	0.282
Breadth*Type broad weak	first	second	0.4414	0.5426	296	0.81	0.4165	1.555
Breadth*Type narrow same	first	second	0.8688	0.5781	296	1.50	0.1339	2.384
Breadth*Type narrow strong	first	second	0.07321	0.5355	296	0.14	0.8913	1.076
Breadth*Type narrow weak	first	second	-0.6961	0.6020	296	-1.16	0.2485	0.499

Table 31: LSM estimates and simple effects of Order*Breadth*Type in Scenario C

Order*Breadth*Type Least Squares Means									
Order	Breadth	Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
f	broad	same	0.1766	0.5374	296	0.33	0.7427	0.5440	0.1333
f	broad	strong	0.1624	0.4912	296	0.33	0.7412	0.5405	0.1220
f	broad	weak	0.6565	0.5399	296	1.22	0.2250	0.6585	0.1214
f	narrow	same	-0.1684	0.5707	296	-0.30	0.7681	0.4580	0.1417
f	narrow	strong	-0.1646	0.4986	296	-0.33	0.7415	0.4589	0.1238
f	narrow	weak	-0.4758	0.5305	296	-0.90	0.3705	0.3832	0.1254
r	broad	same	-0.3332	0.3595	296	-0.93	0.3547	0.4175	0.08742
r	broad	strong	1.0841	0.3776	296	2.87	0.0044	0.7473	0.07131
r	broad	weak	-0.04329	0.3369	296	-0.13	0.8978	0.4892	0.08419
r	narrow	same	0.07532	0.3562	296	0.21	0.8327	0.5188	0.08891
r	narrow	strong	-0.1516	0.3424	296	-0.44	0.6583	0.4622	0.08511
r	narrow	weak	0.7465	0.3897	296	1.92	0.0564	0.6784	0.08501

Simple Effect Comparisons of Order*Breadth*Type Least Squares Means By Order*Breadth								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Order*Breadth f broad	same	strong	0.01416	0.6571	296	0.02	0.9828	1.014
Order*Breadth f broad	same	weak	-0.4799	0.6944	296	-0.69	0.4900	0.619
Order*Breadth f broad	strong	weak	-0.4941	0.6585	296	-0.75	0.4537	0.610
Order*Breadth f narrow	same	strong	-0.00380	0.6914	296	-0.01	0.9956	0.996
Order*Breadth f narrow	same	weak	0.3074	0.7054	296	0.44	0.6633	1.360
Order*Breadth f narrow	strong	weak	0.3112	0.6579	296	0.47	0.6365	1.365
Order*Breadth r broad	same	strong	-1.4174	0.4789	296	-2.96	0.0033	0.242
Order*Breadth r broad	same	weak	-0.2899	0.4485	296	-0.65	0.5185	0.748
Order*Breadth r broad	strong	weak	1.1274	0.4653	296	2.42	0.0160	3.088
Order*Breadth r narrow	same	strong	0.2269	0.4507	296	0.50	0.6150	1.255
Order*Breadth r narrow	same	weak	-0.6712	0.4851	296	-1.38	0.1675	0.511
Order*Breadth r narrow	strong	weak	-0.8981	0.4751	296	-1.89	0.0597	0.407

Table 31: LSM estimates and simple effects of Order*Breadth*Type in Scenario C
(contd.)

Simple Effect Comparisons of Order*Breadth*Type Least Squares Means By Order*Type								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Order*Type f same	broad	narrow	0.3450	0.7126	296	0.48	0.6287	1.412
Order*Type f strong	broad	narrow	0.3270	0.6255	296	0.52	0.6015	1.387
Order*Type f weak	broad	narrow	1.1323	0.6894	296	1.64	0.1016	3.103
Order*Type r same	broad	narrow	-0.4086	0.4612	296	-0.89	0.3764	0.665
Order*Type r strong	broad	narrow	1.2357	0.4675	296	2.64	0.0087	3.441
Order*Type r weak	broad	narrow	-0.7898	0.4742	296	-1.67	0.0969	0.454

Simple Effect Comparisons of Order*Breadth*Type Least Squares Means By Breadth*Type								
Simple Effect Level	Order	Order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth*Type broad same	f	r	0.5098	0.6464	296	0.79	0.4309	1.665
Breadth*Type broad strong	f	r	-0.9217	0.6177	296	-1.49	0.1367	0.398
Breadth*Type broad weak	f	r	0.6998	0.6366	296	1.10	0.2726	2.013
Breadth*Type narrow same	f	r	-0.2437	0.6734	296	-0.36	0.7177	0.784
Breadth*Type narrow strong	f	r	-0.01301	0.6058	296	-0.02	0.9829	0.987
Breadth*Type narrow weak	f	r	-1.2223	0.6585	296	-1.86	0.0644	0.295

Table 32: Type III tests of fixed effects for Scenarios C, D and F

Scenario C				
Effect	Num DF	Den DF	F Value	Pr > F
Order	1	308	0.29	0.5912
Role	1	45	1.01	0.3207
Breadth	1	308	0.77	0.3797
Type	2	308	1.16	0.3157

Scenario D				
Effect	Num DF	Den DF	F Value	Pr > F
Order	1	343	0.97	0.3246
Role	1	44	0.72	0.4017
Breadth	1	343	2.82	0.0943
Type	2	343	0.40	0.6715

Scenario F				
Effect	Num DF	Den DF	F Value	Pr > F
Order	1	382	0.17	0.6797
Role	1	46	3.72	0.0600
Breadth	1	382	0.92	0.3381
Type	2	382	0.06	0.9458

Table 33: Results of licensing occurrence in Scenario E

Type III Tests of Fixed Effects							
Effect	Num DF	Den DF	F Value	Pr > F			
Type	2	357	3.27	0.0392			

Type Least Squares Means							
Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
same	-0.2162	0.1976	357	-1.09	0.2745	0.4462	0.04882
strong	0.2443	0.1984	357	1.23	0.2189	0.5608	0.04886
weak	-0.3528	0.1902	357	-1.85	0.0645	0.4127	0.04610

Differences of Type Least Squares Means							
Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
same	strong	-0.4605	0.2478	357	-1.86	0.0639	0.631
same	weak	0.1365	0.2423	357	0.56	0.5734	1.146
strong	weak	0.5971	0.2427	357	2.46	0.0144	1.817

Table 34: Type III Tests of Fixed Effects of licensing occurrence (aggregate data)

Effect	Num DF	Den DF	F Value	Pr > F
Scenario	5	2521	5.95	<.0001
Order	1	2521	0.80	0.3698
Scenario*Order	5	2521	1.28	0.2704
Role	1	46	0.06	0.8027
Scenario*Role	5	2521	5.61	<.0001
Order*Role	1	2521	0.70	0.4044
Breadth	1	2521	0.07	0.7851
Scenario*Breadth	5	2521	5.22	<.0001
Order*Breadth	1	2521	0.62	0.4293
Role*Breadth	1	2521	1.13	0.2882
Type	2	2521	0.04	0.9603
Scenario*Type	10	2521	1.75	0.0650
Order*Type	2	2521	0.84	0.4329
Role*Type	2	2521	1.61	0.1992
Breadth*Type	2	2521	0.31	0.7347

Table 35: Simple Effect Comparisons of Scenario*Breadth LSM for licensing occurrence (aggregate data)

a. By Scenario								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Scenario A	Broad	narrow	-0.7122	0.2115	2546	-3.37	0.0008	0.491
Scenario B	Broad	narrow	0.5240	0.2052	2546	2.55	0.0107	1.689
Scenario C	Broad	narrow	0.2576	0.2134	2546	1.21	0.2275	1.294
Scenario D	Broad	narrow	0.3894	0.2095	2546	1.86	0.0633	1.476
Scenario E	Broad	narrow	-0.3594	0.2016	2546	-1.78	0.0746	0.698
Scenario F	Broad	narrow	0.2003	0.1981	2546	1.01	0.3121	1.222

b. By Breadth								
Simple Effect Level	Scenario	Scenario	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Breadth broad	A	B	-1.0504	0.2101	2546	-5.00	<.0001	0.350
Breadth broad	A	C	-0.9295	0.2093	2546	-4.44	<.0001	0.395
Breadth broad	A	D	-1.3103	0.2107	2546	-6.22	<.0001	0.270
Breadth broad	A	E	-0.2985	0.2063	2546	-1.45	0.1482	0.742
Breadth broad	A	F	-1.0960	0.2036	2546	-5.38	<.0001	0.334
Breadth broad	B	C	0.1209	0.2101	2546	0.58	0.5649	1.129
Breadth broad	B	D	-0.2598	0.2099	2546	-1.24	0.2159	0.771
Breadth broad	B	E	0.7520	0.2075	2546	3.62	0.0003	2.121
Breadth broad	B	F	-0.04555	0.2029	2546	-0.22	0.8224	0.955
Breadth broad	C	D	-0.3808	0.2103	2546	-1.81	0.0703	0.683
Breadth broad	C	E	0.6310	0.2068	2546	3.05	0.0023	1.880
Breadth broad	C	F	-0.1665	0.2034	2546	-0.82	0.4132	0.847
Breadth broad	D	E	1.0118	0.2082	2546	4.86	<.0001	2.751
Breadth broad	D	F	0.2143	0.2035	2546	1.05	0.2925	1.239
Breadth broad	E	F	-0.7975	0.2009	2546	-3.97	<.0001	0.450
Breadth narrow	A	B	0.1857	0.2082	2546	0.89	0.3725	1.204
Breadth narrow	A	C	0.04030	0.2155	2546	0.19	0.8517	1.041
Breadth narrow	A	D	-0.2088	0.2127	2546	-0.98	0.3264	0.812
Breadth narrow	A	E	0.05425	0.2066	2546	0.26	0.7928	1.056
Breadth narrow	A	F	-0.1835	0.2079	2546	-0.88	0.3776	0.832
Breadth narrow	B	C	-0.1454	0.2106	2546	-0.69	0.4900	0.865
Breadth narrow	B	D	-0.3945	0.2066	2546	-1.91	0.0564	0.674
Breadth narrow	B	E	-0.1314	0.2013	2546	-0.65	0.5138	0.877
Breadth narrow	B	F	-0.3692	0.2016	2546	-1.83	0.0672	0.691
Breadth narrow	C	D	-0.2491	0.2147	2546	-1.16	0.2461	0.780
Breadth narrow	C	E	0.01395	0.2085	2546	0.07	0.9466	1.014
Breadth narrow	C	F	-0.2238	0.2103	2546	-1.06	0.2873	0.799
Breadth narrow	D	E	0.2630	0.2058	2546	1.28	0.2013	1.301
Breadth narrow	D	F	0.02529	0.2062	2546	0.12	0.9024	1.026
Breadth narrow	E	F	-0.2377	0.2010	2546	-1.18	0.2369	0.788

Table 36: Simple Effect Comparisons of Scenario*Role LSM for licensing occurrence (aggregate data)

a. By Scenario								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Scenario A	first	second	-0.8011	0.2755	2546	-2.91	0.0037	0.449
Scenario B	first	second	0.4486	0.2715	2546	1.65	0.0986	1.566
Scenario C	first	second	-0.3029	0.2770	2546	-1.09	0.2742	0.739
Scenario D	first	second	0.2240	0.2760	2546	0.81	0.4171	1.251
Scenario E	first	second	-0.1557	0.2683	2546	-0.58	0.5617	0.856
Scenario F	first	second	0.4729	0.2663	2546	1.78	0.0760	1.605

b. By Role								
Simple Effect Level	Scenario	Scenario	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Role first	A	B	-1.0572	0.2147	2546	-4.92	<.0001	0.347
Role first	A	C	-0.6937	0.2101	2546	-3.30	0.0010	0.500
Role first	A	D	-1.2721	0.2191	2546	-5.81	<.0001	0.280
Role first	A	E	-0.4448	0.2017	2546	-2.20	0.0275	0.641
Role first	A	F	-1.2767	0.2106	2546	-6.06	<.0001	0.279
Role first	B	C	0.3635	0.2174	2546	1.67	0.0946	1.438
Role first	B	D	-0.2149	0.2230	2546	-0.96	0.3354	0.807
Role first	B	E	0.6124	0.2091	2546	2.93	0.0034	1.845
Role first	B	F	-0.2195	0.2146	2546	-1.02	0.3065	0.803
Role first	C	D	-0.5784	0.2214	2546	-2.61	0.0090	0.561
Role first	C	E	0.2489	0.2041	2546	1.22	0.2228	1.283
Role first	C	F	-0.5830	0.2131	2546	-2.74	0.0063	0.558
Role first	D	E	0.8273	0.2136	2546	3.87	0.0001	2.287
Role first	D	F	-0.00463	0.2190	2546	-0.02	0.9831	0.995
Role first	E	F	-0.8319	0.2049	2546	-4.06	<.0001	0.435
Role second	A	B	0.1925	0.2050	2546	0.94	0.3478	1.212
Role second	A	C	-0.1955	0.2147	2546	-0.91	0.3626	0.822
Role second	A	D	-0.2470	0.2062	2546	-1.20	0.2310	0.781
Role second	A	E	0.2006	0.2112	2546	0.95	0.3424	1.222
Role second	A	F	-0.00277	0.2025	2546	-0.01	0.9891	0.997
Role second	B	C	-0.3880	0.2049	2546	-1.89	0.0585	0.678
Role second	B	D	-0.4394	0.1947	2546	-2.26	0.0241	0.644
Role second	B	E	0.008107	0.2013	2546	0.04	0.9679	1.008
Role second	B	F	-0.1952	0.1906	2546	-1.02	0.3057	0.823
Role second	C	D	-0.05147	0.2058	2546	-0.25	0.8025	0.950
Role second	C	E	0.3961	0.2112	2546	1.88	0.0608	1.486
Role second	C	F	0.1927	0.2024	2546	0.95	0.3411	1.213
Role second	D	E	0.4476	0.2028	2546	2.21	0.0274	1.564
Role second	D	F	0.2442	0.1918	2546	1.27	0.2030	1.277
Role second	E	F	-0.2033	0.1990	2546	-1.02	0.3069	0.816

Table 37: LSM estimates of Scenario*Breadth and Scenario*Role in licensing occurrence (aggregate data)

a. Scenario*Breadth Least Squares Means								
Scenario	Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
A	broad	-0.6384	0.1730	2546	-3.69	0.0002	0.3456	0.03913
A	narrow	0.07377	0.1755	2546	0.42	0.6743	0.5184	0.04382
B	broad	0.4120	0.1730	2546	2.38	0.0173	0.6016	0.04147
B	narrow	-0.1119	0.1688	2546	-0.66	0.5074	0.4720	0.04207
C	broad	0.2911	0.1731	2546	1.68	0.0927	0.5723	0.04236
C	narrow	0.03347	0.1781	2546	0.19	0.8510	0.5084	0.04451
D	broad	0.6719	0.1740	2546	3.86	0.0001	0.6619	0.03893
D	narrow	0.2825	0.1740	2546	1.62	0.1046	0.5702	0.04264
E	broad	-0.3399	0.1698	2546	-2.00	0.0455	0.4158	0.04126
E	narrow	0.01951	0.1672	2546	0.12	0.9071	0.5049	0.04180
F	broad	0.4576	0.1652	2546	2.77	0.0056	0.6124	0.03921
F	narrow	0.2572	0.1683	2546	1.53	0.1265	0.5640	0.04139

b. Scenario*Role Least Squares Means								
Scenario	Role	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
A	first	-0.6829	0.1935	2546	-3.53	0.0004	0.3356	0.04315
A	second	0.1182	0.1972	2546	0.60	0.5489	0.5295	0.04913
B	first	0.3744	0.1998	2546	1.87	0.0611	0.5925	0.04823
B	second	-0.07424	0.1853	2546	-0.40	0.6887	0.4814	0.04626
C	first	0.01083	0.1964	2546	0.06	0.9560	0.5027	0.04911
C	second	0.3137	0.1966	2546	1.60	0.1107	0.5778	0.04797
D	first	0.5892	0.2049	2546	2.88	0.0041	0.6432	0.04701
D	second	0.3652	0.1863	2546	1.96	0.0501	0.5903	0.04506
E	first	-0.2381	0.1873	2546	-1.27	0.2037	0.4408	0.04616
E	second	-0.08235	0.1934	2546	-0.43	0.6703	0.4794	0.04828
F	first	0.5938	0.1955	2546	3.04	0.0024	0.6442	0.04481
F	second	0.1210	0.1823	2546	0.66	0.5069	0.5302	0.04540

Table 38: Frequency table of patent challenge decision

a. Table of License by challenge			
License	challenge		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
No	370 10.71 46.48 15.85	426 12.33 53.52 38.04	796 23.05
Yes	1964 56.86 73.89 84.15	694 20.09 26.11 61.96	2658 76.95
Total	2334 67.57	1120 32.43	3454 100.00

c. Table of Breadth by challenge			
Breadth	challenge		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
broad	799 23.13 46.27 34.23	928 26.87 53.73 82.86	1727 50.00
narrow	1535 44.44 88.88 65.77	192 5.56 11.12 17.14	1727 50.00
Total	2334 67.57	1120 32.43	3454 100.00

b. Table of Scenario by challenge			
Scenario	challenge		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
A	344 9.96 59.72 14.74	232 6.72 40.28 20.71	576 16.68
B	392 11.35 68.17 16.80	183 5.30 31.83 16.34	575 16.65
C	390 11.29 67.83 16.71	185 5.36 32.17 16.52	575 16.65
D	426 12.33 73.96 18.25	150 4.34 26.04 13.39	576 16.68
E	356 10.31 61.81 15.25	220 6.37 38.19 19.64	576 16.68
F	426 12.33 73.96 18.25	150 4.34 26.04 13.39	576 16.68
Total	2334 67.57	1120 32.43	3454 100.00

d. Table of Type by challenge			
Type	challenge		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
same	777 22.50 67.45 33.29	375 10.86 32.55 33.48	1152 33.35
strong	821 23.77 71.39 35.18	329 9.53 28.61 29.38	1150 33.29
weak	736 21.31 63.89 31.53	416 12.04 36.11 37.14	1152 33.35
Total	2334 67.57	1120 32.43	3454 100.00

Table 39: LSM estimates and differences of estimates for patent challenge behavior in Scenario A

License Least Squares Means							
License	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
No	0.7410	0.2369	476	3.13	0.0019	0.6772	0.05179
Yes	-1.0477	0.1542	476	-6.80	<.0001	0.2597	0.02964

Differences of License Least Squares Means							
License	License	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
No	Yes	1.7887	0.2886	476	6.20	<.0001	5.982

Type Least Squares Means							
Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
same	-0.3797	0.2010	476	-1.89	0.0595	0.4062	0.04848
strong	-0.5059	0.2054	476	-2.46	0.0141	0.3762	0.04819
weak	0.4256	0.2046	476	2.08	0.0380	0.6048	0.04889

Differences of Type Least Squares Means							
Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
same	strong	0.1262	0.2570	476	0.49	0.6236	1.135
same	weak	-0.8052	0.2585	476	-3.12	0.0019	0.447
strong	weak	-0.9314	0.2612	476	-3.57	0.0004	0.394

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	1.2752	0.1873	476	6.81	<.0001	0.7816	0.03196
narrow	-1.5819	0.1877	476	-8.43	<.0001	0.1705	0.02654

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	2.8571	0.2531	476	11.29	<.0001	17.410

Table 40: LSM estimates for patent challenge in Scenario B

Role*License Least Squares Means								
Role	License	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
first	No	0.8797	0.3714	471	2.37	0.0183	0.7068	0.07697
first	Yes	-2.5533	0.3425	471	-7.45	<.0001	0.07221	0.02295
second	No	0.3297	0.3961	471	0.83	0.4056	0.5817	0.09638
second	Yes	-1.2001	0.1861	471	-6.45	<.0001	0.2315	0.03310

Breadth*Type Least Squares Means								
Breadth	Type	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
broad	same	0.6097	0.2750	471	2.22	0.0271	0.6479	0.06274
broad	strong	1.0524	0.2766	471	3.81	0.0002	0.7412	0.05305
broad	weak	0.6914	0.2758	471	2.51	0.0125	0.6663	0.06132
narrow	same	-2.4454	0.4138	471	-5.91	<.0001	0.07977	0.03038
narrow	strong	-2.6034	0.4121	471	-6.32	<.0001	0.06892	0.02644
narrow	weak	-1.1207	0.3236	471	-3.46	0.0006	0.2459	0.06000

Role*Breadth Least Squares Means								
Role	Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
first	broad	1.2227	0.3097	471	3.95	<.0001	0.7725	0.05442
first	narrow	-2.8963	0.4095	471	-7.07	<.0001	0.05234	0.02031
second	broad	0.3463	0.2556	471	1.35	0.1761	0.5857	0.06203
second	narrow	-1.2167	0.2874	471	-4.23	<.0001	0.2285	0.05067

Table 41: Simple effect comparisons of LSM for patent challenge in Scenario B

Simple Effect Comparisons of Role*License Least Squares Means By Role								
Simple Effect Level	License	License	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role first	No	Yes	3.4330	0.5600	471	6.13	<.0001	30.968
Role second	No	Yes	1.5298	0.4255	471	3.60	0.0004	4.617

Simple Effect Comparisons of Role*License Least Squares Means By License								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
License No	first	second	0.5500	0.5429	471	1.01	0.3115	1.733
License Yes	first	second	-1.3532	0.3856	471	-3.51	0.0005	0.258

Simple Effect Comparisons of Breadth*Type Least Squares Means By Breadth								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	same	strong	-0.4427	0.3242	471	-1.37	0.1727	0.642
Breadth broad	same	weak	-0.08174	0.3304	471	-0.25	0.8047	0.922
Breadth broad	strong	weak	0.3610	0.3261	471	1.11	0.2688	1.435
Breadth narrow	same	strong	0.1579	0.5461	471	0.29	0.7726	1.171
Breadth narrow	same	weak	-1.3247	0.4787	471	-2.77	0.0059	0.266
Breadth narrow	strong	weak	-1.4826	0.4834	471	-3.07	0.0023	0.227

Simple Effect Comparisons of Breadth*Type Least Squares Means By Type								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Type same	broad	narrow	3.0552	0.5009	471	6.10	<.0001	21.224
Type strong	broad	narrow	3.6558	0.5107	471	7.16	<.0001	38.699
Type weak	broad	narrow	1.8122	0.4189	471	4.33	<.0001	6.124

Simple Effect Comparisons of Role*Breadth Least Squares Means By Role								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role first	broad	narrow	4.1190	0.5747	471	7.17	<.0001	61.499
Role second	broad	narrow	1.5631	0.3064	471	5.10	<.0001	4.773

Simple Effect Comparisons of Role*Breadth Least Squares Means By Breadth								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	first	second	0.8764	0.4008	471	2.19	0.0293	2.402
Breadth narrow	first	second	-1.6796	0.4944	471	-3.40	0.0007	0.186

Table 42: LSM estimates for patent challenge in Scenario C

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
broad	0.9247	0.1846	473	5.01	<.0001	0.7160	0.03754
narrow	-2.4951	0.2426	473	-10.28	<.0001	0.07620	0.01708

License Least Squares Means							
License	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
No	0.4875	0.2229	473	2.19	0.0292	0.6195	0.05254
Yes	-2.0579	0.2011	473	-10.23	<.0001	0.1133	0.02020

Role*Type Least Squares Means								
Role	Type	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
first	same	-0.4512	0.2827	473	-1.60	0.1112	0.3891	0.06720
first	strong	-0.7345	0.2907	473	-2.53	0.0118	0.3242	0.06369
first	weak	-0.9440	0.2878	473	-3.28	0.0011	0.2801	0.05803
second	same	-0.6382	0.2844	473	-2.24	0.0253	0.3457	0.06433
second	strong	-1.9102	0.3527	473	-5.42	<.0001	0.1290	0.03962
second	weak	-0.03326	0.2751	473	-0.12	0.9038	0.4917	0.06875

Table 43: Difference of LSM and Simple effect comparisons for patent challenge in Scenario C

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
broad	narrow	3.4198	0.3344	473	10.23	<.0001	30.562

Differences of License Least Squares Means							
License	License	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
No	Yes	2.5454	0.3259	473	7.81	<.0001	12.749

Simple Effect Comparisons of Role*Type Least Squares Means By Role								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Role first	same	strong	0.2834	0.3903	473	0.73	0.4682	1.328
Role first	same	weak	0.4928	0.3902	473	1.26	0.2072	1.637
Role first	strong	weak	0.2095	0.3916	473	0.53	0.5930	1.233
Role second	same	strong	1.2721	0.4366	473	2.91	0.0037	3.568
Role second	same	weak	-0.6049	0.3825	473	-1.58	0.1144	0.546
Role second	strong	weak	-1.8770	0.4356	473	-4.31	<.0001	0.153

Simple Effect Comparisons of Role*Type Least Squares Means By Type								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t 	Odds Ratio
Type same	first	second	0.1870	0.3944	473	0.47	0.6356	1.206
Type strong	first	second	1.1757	0.4439	473	2.65	0.0084	3.240
Type weak	first	second	-0.9107	0.3922	473	-2.32	0.0207	0.402

Table 44: LSM estimates and differences of LSM for patent challenge in Scenario D

License Least Squares Means							
License	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
No	0.1697	0.2610	478	0.65	0.5160	0.5423	0.06479
Yes	-2.2760	0.2184	478	-10.42	<.0001	0.09313	0.01845

Differences of License Least Squares Means							
License	License	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
No	Yes	2.4456	0.3405	478	7.18	<.0001	11.538

Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	0.5578	0.1966	478	2.84	0.0048	0.6359	0.04553
narrow	-2.6640	0.2757	478	-9.66	<.0001	0.06513	0.01678

Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	3.2218	0.3371	478	9.56	<.0001	25.073

Role Least Squares Means							
Role	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
first	-1.3493	0.2148	47	-6.28	<.0001	0.2060	0.03512
second	-0.7570	0.2206	47	-3.43	0.0013	0.3193	0.04796

Differences of Role Least Squares Means							
Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
first	second	-0.5923	0.2719	47	-2.18	0.0344	0.553

Table 45: LSM estimates for patent challenge under Scenario E

License Least Squares Means							
License	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
No	0.2427	0.2949	470	0.82	0.4110	0.5604	0.07266
Yes	-1.2317	0.2000	470	-6.16	<.0001	0.2259	0.03498

Breadth*Type Least Squares Means								
Breadth	Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	same	1.3445	0.3026	470	4.44	<.0001	0.7932	0.04962
broad	strong	0.7511	0.2859	470	2.63	0.0089	0.6794	0.06228
broad	weak	1.2801	0.3075	470	4.16	<.0001	0.7825	0.05235
narrow	same	-2.1469	0.4061	470	-5.29	<.0001	0.1046	0.03804
narrow	strong	-3.2491	0.5419	470	-6.00	<.0001	0.03736	0.01949
narrow	weak	-0.9469	0.3220	470	-2.94	0.0034	0.2795	0.06485

Order*Type Least Squares Means								
Order	Type	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
f	same	-0.4025	0.4594	470	-0.88	0.3814	0.4007	0.1103
f	strong	-1.8991	0.5504	470	-3.45	0.0006	0.1302	0.06234
f	weak	0.4153	0.4040	470	1.03	0.3045	0.6024	0.09676
r	same	-0.3999	0.2677	470	-1.49	0.1360	0.4013	0.06433
r	strong	-0.5989	0.2844	470	-2.11	0.0358	0.3546	0.06509
r	weak	-0.08210	0.2506	470	-0.33	0.7434	0.4795	0.06255

Role*Breadth Least Squares Means								
Role	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
first	broad	1.2410	0.2760	470	4.50	<.0001	0.7757	0.04801
first	narrow	-2.4847	0.3940	470	-6.31	<.0001	0.07694	0.02798
second	broad	1.0095	0.2646	470	3.82	0.0002	0.7329	0.05179
second	narrow	-1.7439	0.3335	470	-5.23	<.0001	0.1488	0.04224

Order*Breadth Least Squares Means								
Order	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
f	broad	1.3103	0.3355	470	3.91	0.0001	0.7876	0.05613
f	narrow	-2.5679	0.5063	470	-5.07	<.0001	0.07123	0.03349
r	broad	0.9401	0.2187	470	4.30	<.0001	0.7191	0.04417
r	narrow	-1.6607	0.2554	470	-6.50	<.0001	0.1597	0.03426

Table 46: Difference of LSM and simple effect comparisons of LSM for patent challenge under Scenario E

Differences of License Least Squares Means							
License	License	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
No	Yes	1.4744	0.3070	470	4.80	<.0001	4.369

Simple Effect Comparisons of Breadth*Type Least Squares Means By Breadth								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	same	strong	0.5934	0.3592	470	1.65	0.0992	1.810
Breadth broad	same	weak	0.06444	0.3612	470	0.18	0.8585	1.067
Breadth broad	strong	weak	-0.5289	0.3577	470	-1.48	0.1399	0.589
Breadth narrow	same	strong	1.1022	0.6056	470	1.82	0.0694	3.011
Breadth narrow	same	weak	-1.2000	0.4655	470	-2.58	0.0102	0.301
Breadth narrow	strong	weak	-2.3022	0.5742	470	-4.01	<.0001	0.100

Simple Effect Comparisons of Breadth*Type Least Squares Means By Type								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Type same	broad	narrow	3.4914	0.4591	470	7.60	<.0001	32.832
Type strong	broad	narrow	4.0002	0.5642	470	7.09	<.0001	54.610
Type weak	broad	narrow	2.2269	0.3840	470	5.80	<.0001	9.271

Simple Effect Comparisons of Order*Type Least Squares Means By Order								
Simple Effect Level	Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Order f	same	strong	1.4966	0.6260	470	2.39	0.0172	4.466
Order f	same	weak	-0.8178	0.5394	470	-1.52	0.1301	0.441
Order f	strong	weak	-2.3144	0.6172	470	-3.75	0.0002	0.099
Order r	same	strong	0.1990	0.3442	470	0.58	0.5634	1.220
Order r	same	weak	-0.3178	0.3078	470	-1.03	0.3024	0.728
Order r	strong	weak	-0.5168	0.3268	470	-1.58	0.1145	0.596

Simple Effect Comparisons of Order*Type Least Squares Means By Type								
Simple Effect Level	Order	Order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Type same	f	r	-0.00265	0.5132	470	-0.01	0.9959	0.997
Type strong	f	r	-1.3002	0.5790	470	-2.25	0.0252	0.272
Type weak	f	r	0.4974	0.4504	470	1.10	0.2700	1.644

Simple Effect Comparisons of Role*Breadth Least Squares Means By Role								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Role first	broad	narrow	3.7257	0.4307	470	8.65	<.0001	41.499
Role second	broad	narrow	2.7534	0.3703	470	7.44	<.0001	15.696

Table 46: Difference of LSM and simple effect comparisons of LSM for patent challenge under Scenario E (contd.)

Simple Effect Comparisons of Role*Breadth Least Squares Means By Breadth								
Simple Effect Level	Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	first	second	0.2314	0.3277	470	0.71	0.4803	1.260
Breadth narrow	first	second	-0.7408	0.4348	470	-1.70	0.0891	0.477

Simple Effect Comparisons of Order*Breadth Least Squares Means By Order								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Order f	broad	narrow	3.8782	0.5545	470	6.99	<.0001	48.338
Order r	broad	narrow	2.6008	0.2848	470	9.13	<.0001	13.475

Simple Effect Comparisons of Order*Breadth Least Squares Means By Breadth								
Simple Effect Level	Order	Order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	f	r	0.3702	0.3684	470	1.00	0.3155	1.448
Breadth narrow	f	r	-0.9072	0.5470	470	-1.66	0.0979	0.404

Table 47: LSM estimates and simple effect comparison of LSM for patent challenge under Scenario F

Breadth*License Least Squares Means								
Breadth	License	Estimate	Standard Error	DF	t Value	Pr > t	Mean	Standard Error Mean
broad	No	1.9048	0.4758	477	4.00	<.0001	0.8704	0.05366
broad	Yes	-0.5647	0.1687	477	-3.35	0.0009	0.3625	0.03898
narrow	No	-2.3752	0.4988	477	-4.76	<.0001	0.08509	0.03883
narrow	Yes	-2.6124	0.2706	477	-9.65	<.0001	0.06835	0.01723

Simple Effect Comparisons of Breadth*License Least Squares Means By Breadth								
Simple Effect Level	License	License	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
Breadth broad	No	Yes	2.4695	0.4910	477	5.03	<.0001	11.816
Breadth narrow	No	Yes	0.2372	0.5546	477	0.43	0.6691	1.268

Simple Effect Comparisons of Breadth*License Least Squares Means By License								
Simple Effect Level	Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
License No	broad	narrow	4.2799	0.6636	477	6.45	<.0001	72.235
License Yes	broad	narrow	2.0477	0.2856	477	7.17	<.0001	7.750

Table 48: Frequency table of litigation decision

a. Table of License by litigation			
License	litigation		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
No	71	355	426
	6.34	31.70	38.04
	16.67	83.33	
	39.89	37.69	
Yes	107	587	694
	9.55	52.41	61.96
	15.42	84.58	
	60.11	62.31	
Total	178	942	1120
	15.89	84.11	100.00

c. Table of Breadth by litigation			
Breadth	litigation		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
broad	168	760	928
	15.00	67.86	82.86
	18.10	81.90	
	94.38	80.68	
narrow	10	182	192
	0.89	16.25	17.14
	5.21	94.79	
	5.62	19.32	
Total	178	942	1120
	15.89	84.11	100.00

b. Table of Scenario by litigation			
Scenario	litigation		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
A	33	199	232
	2.95	17.77	20.71
	14.22	85.78	
	18.54	21.13	
B	33	150	183
	2.95	13.39	16.34
	18.03	81.97	
	18.54	15.92	
C	27	158	185
	2.41	14.11	16.52
	14.59	85.41	
	15.17	16.77	
D	25	125	150
	2.23	11.16	13.39
	16.67	83.33	
	14.04	13.27	
E	36	184	220
	3.21	16.43	19.64
	16.36	83.64	
	20.22	19.53	
F	24	126	150
	2.14	11.25	13.39
	16.00	84.00	
	13.48	13.38	
Total	178	942	1120
	15.89	84.11	100.00

d. Table of Type by litigation			
Type	litigation		
1.Frequency			
2.%			
3.%Row			
4.%Col	0	1	Total
same	72	303	375
	6.43	27.05	33.48
	19.20	80.80	
	40.45	32.17	
strong	31	298	329
	2.77	26.61	29.38
	9.42	90.58	
	17.42	31.63	
weak	75	341	416
	6.70	30.45	37.14
	18.03	81.97	
	42.13	36.20	
Total	178	942	1120
	15.89	84.11	100.00

Table 49: Type III tests of Fixed Effects for patent litigation

Effect	Num DF	Den DF	F Value	Pr > F
Scenario	5	1015	1.61	0.1539
Order	1	1015	5.29	0.0216
Role	1	47	10.30	0.0024
Breadth	1	1015	18.21	<.0001
Type	2	1015	10.54	<.0001
License	1	1015	0.01	0.9261

Table 50: Differences of significant terms Order Least Squares Means

a. Differences of Order Least Squares Means							
Order	Order	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
f	r	0.8727	0.3814	1021	2.29	0.0223	2.393

b. Differences of Role Least Squares Means							
Role	Role	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
first	second	-1.1129	0.3379	47	-3.29	0.0019	0.329

c. Differences of Breadth Least Squares Means							
Breadth	Breadth	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
broad	narrow	-1.6789	0.3973	1021	-4.23	<.0001	0.187

d. Differences of Type Least Squares Means							
Type	Type	Estimate	Standard Error	DF	t Value	Pr > t	Odds Ratio
same	strong	-1.0058	0.2572	1021	-3.91	<.0001	0.366
same	weak	0.06207	0.2110	1021	0.29	0.7687	1.064
strong	weak	1.0678	0.2564	1021	4.17	<.0001	2.909

Table 51: LSM for patent litigation

a. Order Least Squares Means							
Order	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
f	3.3963	0.3816	1021	8.90	<.0001	0.9676	0.01197
r	2.5236	0.2602	1021	9.70	<.0001	0.9258	0.01788

b. Role Least Squares Means							
Role	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
first	2.4035	0.2999	47	8.01	<.0001	0.9171	0.02281
second	3.5164	0.3282	47	10.71	<.0001	0.9711	0.009196

c. Breadth Least Squares Means							
Breadth	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
broad	2.1205	0.1974	1021	10.74	<.0001	0.8929	0.01888
narrow	3.7994	0.4249	1021	8.94	<.0001	0.9781	0.009099

d. Type Least Squares Means							
Type	Estimate	Standard Error	DF	t Value	Pr > t 	Mean	Standard Error Mean
same	2.6454	0.2855	1021	9.27	<.0001	0.9337	0.01767
strong	3.6511	0.3306	1021	11.05	<.0001	0.9747	0.008153
weak	2.5833	0.2809	1021	9.20	<.0001	0.9298	0.01834